Geo J Rhodes

Electrical Engineering

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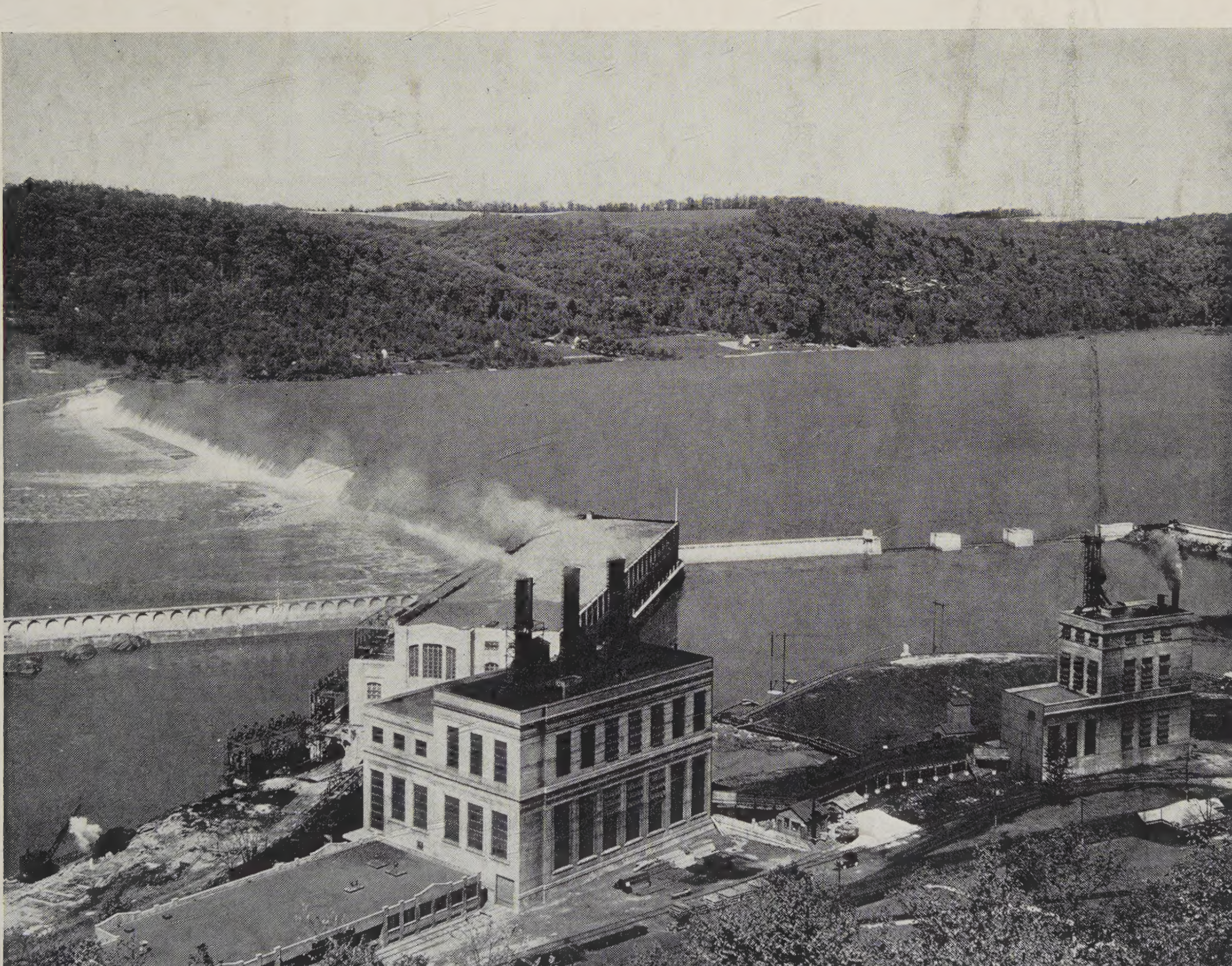

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Future Meetings of the American Institute of Electrical Engineers

Place	Date	Nature	Manuscript Closing Date
Baltimore, Md.	October 10-13, 1932	District Meeting	(Closed)
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	Oct. 23, 1932
Schenectady, N. Y.	May 1933	District Meeting	Feb. 1933
Chicago, Ill.	June 25-30, 1933	Summer Convention	March 25, 1933
Salt Lake City, Utah	Aug.-Sept. 1933	Pacific Coast Convention	May-June 1933

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Assn. for the Advancement of Science, annual convention	Atlantic City, N. J.	Dec. 27–31	C. F. Roos, Permanent Secy., Smithsonian Inst., Washington, D. C.
American Institue of Mining Engineers, annual meeting	New York, N. Y.	Feb. 20–24, 1933	A. B. Parsons, Secy., 29 West 39th St., New York, N. Y.
American Physical Society	Chicago, Ill.	Nov. 25–26	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Physical Society	Pasadena, Calif.	Dec. 16–17	L. B. Loeb, Pacific Coast Secy., Univ. of California, Berkeley, Calif.
American Physical Society, annual meeting	Atlantic City, N. J.	Dec. 28–30	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Society of Civil Engineers, annual meeting	New York, N. Y.	Jan. 18–21 1933	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y
American Society of Mech. Engrs., annual meeting	New York, N. Y.	Dec. 5–9	C. W. Rice, Secy., 29 W. 39th St., New York, N. Y.
National Assn. of Practical Refrigeration Engineers, annual meeting	Chicago, Ill.	Nov. 1–4 1933	Edw. H. Fox, N. A. P. R. E., 435 N. Waller Ave., Chicago, Ill.
National Assn. of Railroad and Utilities Commissioners, annual meeting	Hot Springs, Ark.	Nov. 15–18 1932	J. B. Walker, Secy., 270 Madison Ave., New York, N. Y.
Pacific Coast Electrical Assn., Engineering Section	San Francisco, Calif.	Oct. 19–21 1932	K. I. Dazey, 447 Sutter St., San Francisco, Calif.

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This Month—

Front Cover

Holtwood hydroelectric and steam plant of the Pennsylvania Water and Power Company, at McCall's Ferry, Pa. The Holtwood hydroelectric plant was the first major development on the Susquehanna River, and lies between the Conowingo and Safe Harbor plants. The hydroelectric plant operates under a head of about 53 ft, the total installed capacity of steam and hydroelectric units being 135,000 kw.

—Turn to Next Page

A.I.E.E. Section and Branch activities continue to "take the Institute to the membership." About 80 per cent of all members now are located within Section territory. Cooperative relations between Sections and neighboring Branches have continued to receive much attention. *p. 738–40*

SUGGESTIONS for the nomination of 1933 A.I.E.E. officers must be received at Institute headquarters not later than November 15, 1932. *p. 736–7*

TO ASSIST engineering readers who are interested in economics and sociology, The Engineering Foundation has prepared a list of books and references covering a variety of subjects and views in these fields. *p. 745–6*

THERE is a need today for variety in technical education; the development of adult or evening instruction in metropolitan areas is said to offer a partial solution for meeting this need. *p. 698–1*

NOISE measurements are extremely helpful in the present day "war on noise"; such measurements are beginning to be used as a basis of acceptable "quietness," and provide the principal means of detecting noise sources. *p. 705–8*

SPECIALLY designed supporting towers were required to carry electric power transmission lines into the city of Milwaukee over railway right-of-way. *p. 708–11*

HARMFUL vibration in electric power transmission lines can be controlled effectively by properly installed Stockbridge dampers of suitable design. Difficulties experienced with early designs of this damper have been overcome by the use of a high strength steel supporting cable. *p. 696–7*

ABOUT 2,500 persons are estimated to suffer from electric shock annually in the United States; approximately half of that number suffer fatal injuries. Experimental work for determining effective remedial measures to reduce this toll are being continued. *p. 693–6*

DOUBLE conductor electric power transmission lines have about 20 per cent less reactance than single conductor lines having the same weight of conducting metal, but cost more. Formulas have been developed for calculating the electrical characteristics of such lines. *p. 701–4*

FROM the standpoint of interruption to customers, protection of electric power distribution systems from disturbances due to lightning is a problem of major importance. Operating experience shows that lightning arresters provide sufficient protection to justify their installation economically. *p. 716–27*

PIONEERING in the use of large capacity automatically adjustable blade turbines of the propeller type, the Safe Harbor hydroelectric development involved an unusual amount of experimental and engineering study. Limited experience with this type of turbine in this country led to the construction of a hydraulic laboratory for testing model turbines complete with scroll case and draft tube. *p. 728–33*

ATTENDANCE at the 1932 Pacific Coast convention concluded at Vancouver, B. C., on September 2, reached a total of 300 persons—a fitting tribute to the unremitting efforts of the committees in charge. The convention was featured by the usual high quality technical sessions, active student participation, interesting inspection trips, and delightful entertainment and sports events. *p. 734–6*. Some of the discussion presented at technical sessions has been summarized. *p. 737–8*

115-Kv Submarine Cable for Columbia River Crossing

Outstanding among cable installations is the recently completed 115-kv oil filled submarine cable which crosses the Columbia River between the states of Washington and Oregon. Three single-conductor hollow-core 750,000-cir-mil cables having armor wires of hard drawn copper instead of steel, are laid directly on the bed of the river 4 ft apart, and cross 2 channels of the river, 3,460 and 1,360 ft in width. These crossings are connected by an overhead transmission line. A 33-ft maximum difference in the water level of the river necessitated the solution of a number of problems at this installation. The many interesting features are described in this article, which is divided into 4 main sections. The first section describes the general reasons for the principal decisions regarding the cable, the second describes the specifications and manufacture, the third describes the design of the field installation, and the fourth covers installation and construction methods. Each section contributes valuable information in its respective field.

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DELIVERY of electric energy from e new Ariel plant of the Inland Power & Light ompany on the Lewis River, Wash., to the load nter of the Northwestern Electric Company in ortland, Ore., made necessary the construction of proximately 36 miles of transmission line including 115-kv submarine cable circuit crossing the Colum- a River. The crossing site is just north of Portland y limits and about one mile west of Vancouver, ash. The river, one of North America's largest eams, forms the boundary between the states of egon and Washington.

At the crossing location, shown in Figs. 1 and 2, the er is divided by the $^1/_2$-mile wide Hayden Island o 2 channels, the north channel being 3,460 ft in dth and the south channel 1,360 ft. Two separate ossings, one across either channel, were therefore quired. These were connected by an *H*-frame od pole type transmission line as study had shown is to be more economical than to continue the ble underground across the island.

The selection of a nominal voltage of 110 kv for the nsmission voltage was determined by an economic alysis of costs at various voltages for delivering ergy from Ariel and other possible adjacent de- lopments to load centers in the Portland area; also m consideration of interconnected operation with ner utilities in the Northwest. This later consideration has a very important bearing upon the problem since all of the other major companies are now operating or contemplate conversion of principal trunk lines to nominal 110-kv operation. Furthermore, physical interconnections already exist between all of these companies and interconnected operation has been employed for several years past, so the economic advantages to be gained and necessity for planning to meet the increasing demands for interchange capacity have been clearly demonstrated.

For the construction program necessary to meet the load and service requirements, cost comparisons between crossing the river overhead or submarine clearly established the economy of the submarine method. Factors contributing to this were: the requirement of 198 ft minimum clearance above low water; the flat terrain at the crossing site or anywhere in the vicinity; the small increment of cost for a double circuit overhead crossing over a single circuit, making construction for 2 circuits the logical procedure although only one was needed initially; and the unusual requirements of mechanical strength for the overhead construction on account of the occasional very severe ice loading conditions experienced.

Very careful and thorough consideration was given to the idea of trenching of cables in the river bottom in order to provide protection from ship anchors and other forms of external damage. With present river depth at minus 28 ft el (low water at 0) it was decided that the trench would have to be excavated to minus 40 ft el in order to be beneath future ship channel

text of "115-Kv Submarine Crossing of the Columbia River" (No. 32-125) ented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 13, 1932.

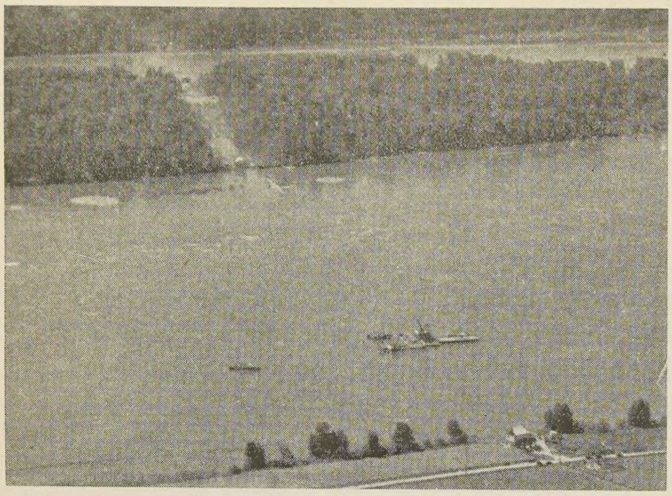


Fig. 1. Site of the 115-kv submarine cable crossing the Columbia River, viewed from the Washington side during construction

bed as well as out of reach of projecting anchor and dredge cutter heads. Such a trench constructed 7 ft wide on the bottom with walls of 1 : 3 slope for withstanding river current would cost from $40,000 to $50,000 and there would be no definite assurance that the trench at right angles to the current could be kept open during laying without additional expenditures for sheet piling or for removing extra sand yardage.

With the cables covered in a trench to minus 40 ft el it is believed that it would not be economically practical to salvage the cable in case defects developed. This fact would therefore necessitate the abandonment of that cable and the writing off of a comparatively large investment. With oil filled cable laid directly on the bed of the river it is believed that the cable can be lifted readily and repaired in case of fault developing. The Northwestern Electric Company has an experience record of 92 submarine cable years covering 11 3-phase 11,000-volt submarine cables laid directly on the beds of the Columbia and Williamette Rivers in the general vicinity of the new crossing. This experience record, excluding pothead failures, discloses only one failure. In that case failure occurred when the cable was accidentally picked up by a sand digger clam shell. This favorable experience record, combined with greater accessibility and less chance of abandonment, together with fixed charge savings of from $5,200 to $6,500 per yr were responsible for the decision to lay the cable directly on the bed of the river.

During the 3-yr study of this problem considerable time was devoted to consideration of the relative merits of cable with solid type of insulation versus oil filled type. The experience and advice of high voltage cable specialists in several manufacturing and utility organizations throughout the United States was sought. Final decision to specify oil filled cable was based on the following facts:

1. Most favorable operating records of oil filled cable over the past 4 yr, particularly when compared with solid type cable operating at high voltage.

2. High electrical endurance strength of oil filled cable as demonstrated in laboratory and field tests.

3. Ability of oil filled cable to maintain perfect impregnation and prevent void formation and ionization.

4. Development of a satisfactory joint for oil filled type submarine cable.

Three cables were laid directly on the bed of the river 4 ft apart and the shore ends above extreme low water were trenched in and covered with 4 ft of sand. Some slack in the shore ends was provided for use in case of channel changes by the scouring action of the river or by dredging operations.

Design and Manufacture of the Columbia River Cable

THE hollow core, single conductor, oil filled cable for the 115-kv submarine crossing of the Columbia River has the following specifications and calculated dimensions:

Inside diam of copper supporting spiral, 0.690 in.
Inside diam of conductor strands, 0.790 in.
Outside diam of conductor strands, 1.277 in.
Conductor cross section, 750,000 cir mils.
Thickness of wood pulp paper insulation, 0.560 in. (nominal).
Perforated copper shielding tape (0.005 in.) interlocked with one paper tape.
Inside diam of lead sheath, 2.497 in.
Outside diam of lead sheath, 2.810 in.
Lead sheath $^{5}/_{32}$ in. 2 per cent tin-lead alloy.
Two layers 16/3 ply tarred jute and asphalt.
Hard drawn copper wire armor (0.238 in. diam).
One layer 16/3 ply tarred jute, asphalt, and whiting.
Overall diam, 3.80 in.
Weight, 20 lb per ft.
Voltage rating, 115 kv, 3 phase, grounded neutral.

Seven reel lengths were manufactured and each length included not only the amount required for installation but also additional cable for test purposes. As manufactured, 3 lengths were approximately 3,780 ft each, 3 more were approximately 1,600 ft and the remaining 832-ft length was shipped on a separate reel to be held in reserve for possible future emergency repair work.

The lead sheath was applied before drying and impregnation treatment. Each length was placed in a steam chamber. Vacuum was applied at each end of the hollow core and drying continued until all moisture was removed. Due to the long lengths involved this drying treatment was necessarily slow, the 3,780 ft lengths requiring 391 hr. After drying impregnation was completed with carefully selected degasified oil having the following characteristics:

Specific gravity, 0.91
Viscosity at 37.8 deg C, 100 (Saybolt)
Pour point, −40 deg C

Following the usual practise, the oil in the core, after impregnation was completed, was continuously maintained under positive pressure by use of one or more cell type pressure reservoir units connected to the cable end. The first principle of oil filled cable practise is to always maintain positive oil pressure at all points of cable length in the factory and during shipment, installation, and operation. The various operations that are closely followed throughout are solely for the purpose of initially removing air,

oisture, and other impurities from the entire system, mpletely filling with oil and maintaining positive oil essure, so that additional impurities cannot enter rough accidental leaks.

After impregnation the cable lengths were sub- cted to a special volumetric pressure test for assur- ice that all air and other gases had been removed. he complete lengths or test samples cut from the ids were then subjected to various special and andard acceptance tests, chief among which were e following:

Factory reel high potential test, 166,000 volts conductor to eath for 15 min at 60 cycles, before armoring.

Dielectric power factor and ionization factor, 20 to 100 volts per il, 60 cycles on each reel length before and after armoring. Ioniza- on factor limit 0.2 per cent actual 0 per cent.

High voltage time test. Three 75 ft lengths, one before and after armoring. 196,000 volts for 6 hr with 20 per cent voltage eps every 6 hr to failure. The samples failed at 235 kv in 2, 3, d 5 hr.

Two 25 ft samples before armoring for 60 cycle dielectric loss st. The average measured power factor was: 0.32 per cent at om temperature, 0.27 per cent at 60 deg C, 0.28 per cent at 70 g C and 0.30 per cent at 80 deg C.

Three 15 ft samples, 2 before and 1 after armoring for bending st. Four cycles of 180° bending at −10 deg C around a mandril times cable diameter. Physical condition noted but electrical sts omitted as meaningless.

After test the 7 shipping lengths were as follows: lengths 3,717 ft each, 3 1,532 ft each, and 1 spare 32 ft length. Each was placed on a separate reel in e body of which was mounted a sufficient number cell type pressure reservoir units to maintain an l pressure between 5 lb and 15 lb during shipment id installation. All shipping reel bodies were 7 ft in. wide. The 3 reels for 3,717 ft lengths were ft 2 in. in diameter, and the remaining 4 had a ameter of 9 ft 6 in. Each reel was axially mounted a permanent cradle with band brakes for unreeling ıble. Due to excessive size and shipping weight $5^3/_4$ tons for 3,717 ft units and $21^1/_2$ tons for 1,532 ft iits, it was necessary to use special gondola freight rs and load only one reel per car. Obviously, such cessive size and weight required special manu- cturing facilities throughout and the various opera- ons presented a very interesting and difficult prob- m.

ARRYING CAPACITY OF CABLE

The carrying capacity of a submarine cable, where e same size conductor is used throughout, is de- rmined by the thermal conditions at the shore ends, e temperature rise of immersed section being, of urse, much less. The carrying capacity of this rticular installation was more difficult to determine an usual because of the relatively short vertical sers at the ends representing the limiting thermal nditions. Due to transfer of heat from these posed vertical risers into the earth, the usual rmulas for cable in air do not apply exactly and the ermal correction factor was checked by heat run ter installation. On the basis of an ambient air mperature of 40.5 deg C, this cable has a conserva- ve rating of 575 amp for maximum conductor tem- rature of 70 deg C at vertical risers and with copper mor bonded at base of terminals.

If steel armor had been used under the same conditions, the rating would have been only 430 amp, due to excessive armor and sheath losses. The advantages of low resistance copper armor in this respect are fully described in "Losses in Armored Single Conductor Lead Covered A-C Cables," by O. R. Schurig, H. P. Kuehni, and F. H. Buller, A.I.E.E. TRANSACTIONS, v. 48, 1929, p. 417–34.

ACCESSORY DESIGN AND MANUFACTURE

The following accessories and special installation and maintenance treating equipment were also furnished:

14 single conductor outdoor porcelain terminals or potheads.

6 6 gal and 8 10 gal gravity cell type oil feeding reservoirs.

4 10 gal cell type oil pressure reservoirs for maintaining pressure on emergency oil supply tanks at each terminal.

8 50 gal emergency oil supply tanks with oil level gages, nitrogen gas cylinders, valves, fittings, etc., connected 2 in parallel at each terminal.

800 gal special oil in 50 gal drums for filling terminal equipment after assembly.

4 valve panels (6 valves each) for emergency paralleling or interchange of oil feed for each phase.

2 repair joints with armor box and clamping rings.

Copper tubing, armored lead piping, valves and miscellaneous fittings for connecting oil system.

1 portable, motor driven oil degasifier.

1 portable, motor driven vacuum pump.

1 impregnating bottle.

Rubber vacuum hose, toggle clamps, tanks of specially dried carbon dioxide and miscellaneous fittings.

The outdoor potheads were rated at 132 kv, following the usual practise of using one size larger

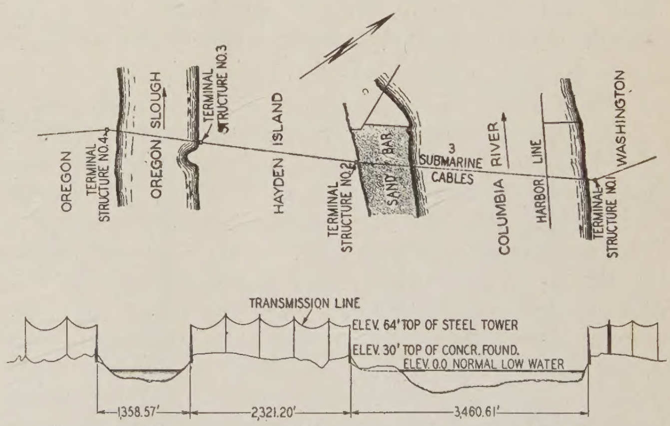


Fig. 2. Plan and profile of the 115-kv submarine cable crossing

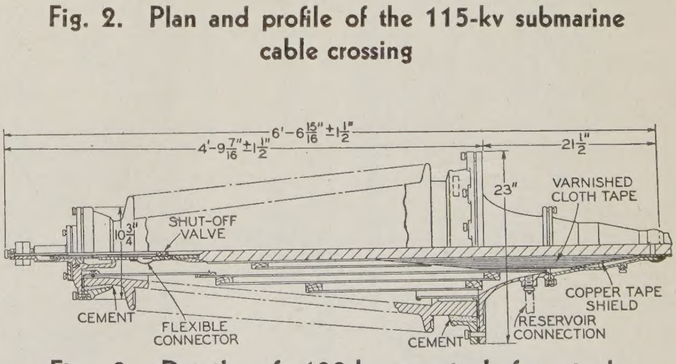


Fig. 3. Details of 132-kv terminal for single conductor oil filled cable

porcelain. A cross sectional drawing of this design is shown in Fig. 3. The guaranteed dry and wet 60 cycle flashover was 375 kv and 280 kv, respectively, and before shipment the potheads were subjected to the following test for leakage: 4 hr vacuum followed by 2 hr oil pressure at 80 deg C. The terminal lugs had a flexible type stud to allow limited movement of the cable conductor during expansion and contraction. There was also a special shut-off valve in the stud so that oil pressure could be maintained in the cable core while the terminal was being vacuum treated and filled with degasified oil after assembly.

All reservoir units, piping fittings, and other accessories were also subjected to rigid tests for leaks before shipment. They were again tested after installation and then carefully dried, evacuated, and filled with degasified oil. The cell type reservoir designs have been described in detail in "Characteristics of Oil Filled Cable," by G. B. Shanklin and F. H. Buller, A.I.E.E. Transactions, v. 50, 1931, p. 1, 411–20; and "Oil Pressure Reservoirs for Underground Cable," by T. C. Aitchison, *General Electric Review*, July 1931, p. 410–15. The first of these also gives a general outline of the principles of oil filled cable practise, and a complete bibliography.

Design of Field Installation for the Columbia River Cable

THE 4 terminal structures of the 115-kv submarine cable crossing of the Columbia River consist of reinforced concrete bases and platforms supporting cable terminals and accessories, and steel dead end structures for the overhead lines. The details of the terminal structures are shown in Fig. 4. The decks of these 4 structures are all at the same elevation and are above the usual high water level, but the lower portions will be submerged at high water. The deck of each structure is surrounded by a barrier of steel plate to protect the potheads and accessories from bullets of youthful sportsmen who frequent the neighborhood, and facing the water is a large sign warning against anchorage.

The structure on the Washington side of the main channel has a foundation of wooden piles. This structure is nearer to the water's edge than the others and is adjacent to the ship channel. No piles are used underneath the other structures. Jetties or dykes for protection against undercutting and damage by floating objects during flood periods will be provided for the structures on both sides of the main river channel when deemed necessary.

The steel dead end overhead structures are mounted on the decks of the concrete terminal structures. They are self-supporting and are designed to withstand the maximum expected strain under heavy ice loading of the 795,000 cir mil A.C.S.R. overhead conductors. To guard against failure from unforeseen loading conditions each conductor is dead-ended through a shearpin designed to fail at the value corresponding to the maximum safe strain on the structure.

Anchoring

Anchoring of the cables is accomplished by the use of 2 concrete dead-men at each terminal structure. Chains are carried back from these dead-men to the 3 cables. Attachment to the cables is made by means of basket grips, this attachment being considered sufficient due to the fact that a considerable section of cable between the structures and the water's edge is buried in the sandy river bank, which will take up a considerable amount of pulling tension.

Bonding and Grounding

Due to the fact that the cable armor is hard drawn copper some special problems were encountered in the bonding and grounding of this installation. During operation the armor carries a current almost as great as that in the conductor and for this reason carefully designed and installed high capacity bonds are necessary.

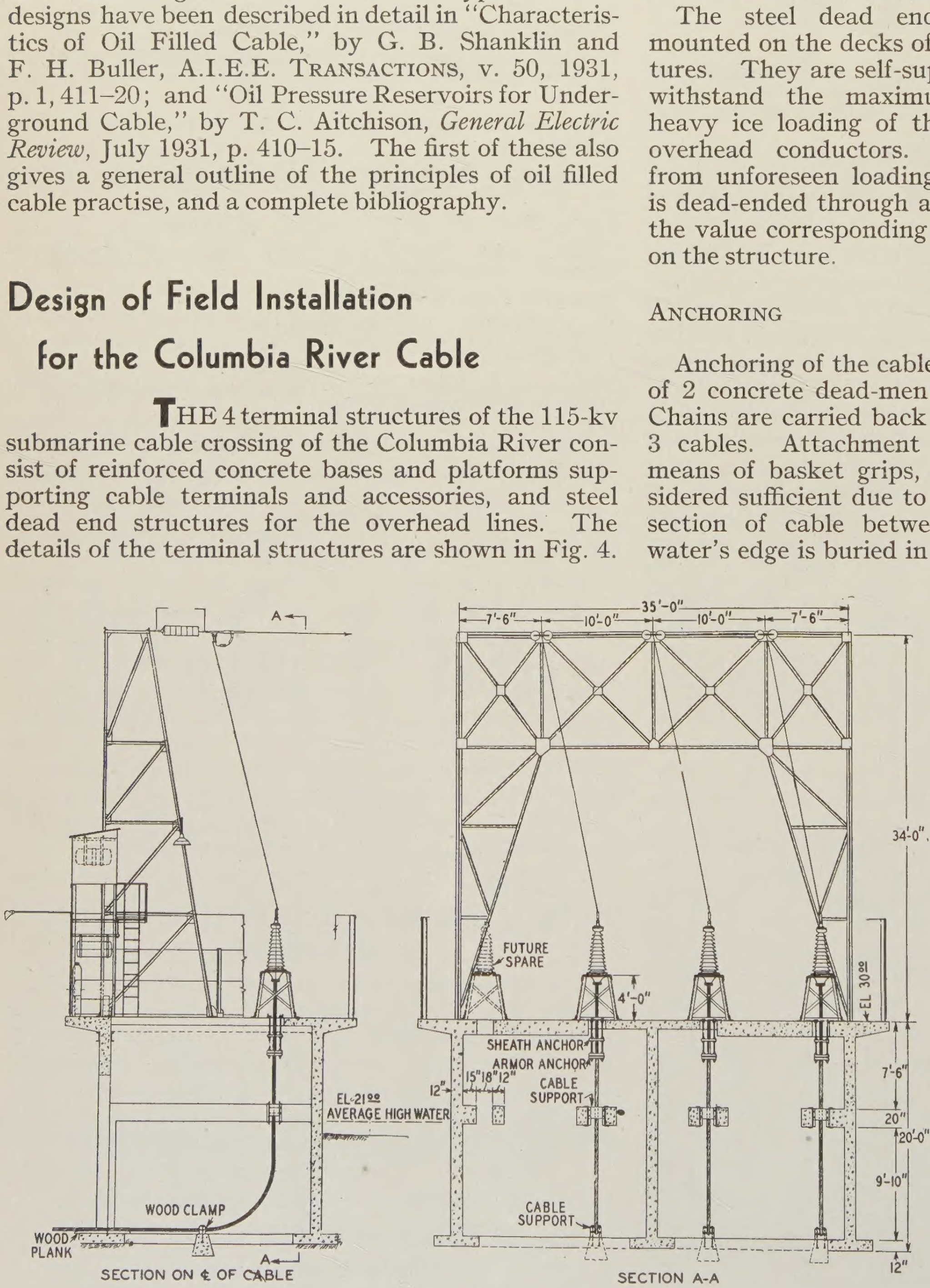


Fig. 4. Outline of design for terminal structures. Structure No. 1 differs slightly, having a foundation of wooden piles

areful study of probable electrolysis conditions, cluding analysis of the river water, indicated at there should be very little corrosion due to ectrolysis. The water has a comparatively high lphate content. If electrolysis does have a tenency to start at any point, the lead sheath soon ecomes coated with a tough, permanent film of lead lphate, thus automatically stopping the action. owever, since with copper armor any corrosion hich might occur would affect the anodic lead eath and not the armor, it was considered advisable take all possible precautions against damage by rrosion. To this end the armor strands of the 3 bles are bonded together at each end separately om the sheaths, the latter also being bonded gether separately and grounded. The 2 sets of onds are connected together by a removable jumper, oth armor and sheath being grounded when this mper is in place. The idea of this arrangement is permit periodically inserting an ammeter between e armor and sheath and testing for electrolysis urrents. If appreciable currents should develop e sheath and the armor can then be separated by moving the jumper or they can be connected rough a battery supplying a potential which is unter to the electrolysis potential.

Arrangement of the grounding system is shown in ig. 5. The ground electrodes consist of a series of iven rods interconnected with each other and with l equipment and structures, forming a low resistance ounding network.

IGHTNING PROTECTION

The lightning protection for the cables and terinals consists of simple spillway gaps mounted ross the dead end insulator strings at each terinal structure. They are well grounded to the ounding network which, in turn, provides a short d effective connection to the cable sheaths. The p setting for operation at 115 kv is 30 in. between oints, this being considerably below the impulse sulation strength of the cable and terminals and so somewhat below the maximum recommended tting of 36 in. given by the manufacturer of the ble and accessories. It is also somewhat higher an the maximum expected switching surge voltes, so that lightning should be the only cause for ashover. Flashover of these gaps may involve a ip-out of the transmission circuit in a manner milar to that of a lightning stroke occurring at any her point of the line.

On account of the fog and contamination condition isting along the river, a leakage distance of 80 in., uivalent to 1.2 in. per kv to ground, is provided on e terminal bushings. Two strings in yoke each of suspension units giving leakage distance of approxiately 90 in. are used on the dead ends. No pedestal sulators are required with the simple structure sign employed.

L LEVEL ALARM SYSTEM

Since the installation is somewhat remote from the arest attended substation it was considered advis-

Fig. 5. Bonding and jointing arrangements at terminal structures

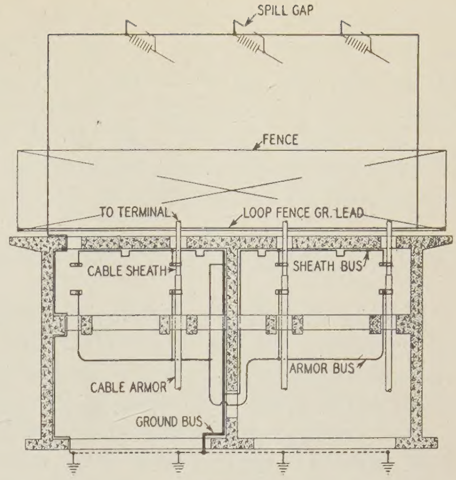
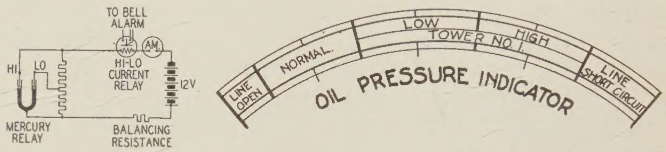


Fig. 6. (Below) Oil pressure signal system and indicator ammeter scale



able to provide remote indication of oil level conditions in the oil reservoirs. Such indication is provided by alarm devices at the oil reservoirs, which devices are connected to telephone lines terminating in Vancouver substation. By a system of resistances individual indication of the different reservoirs can be given over a single telephone line from a given location, the indications being obtained by an ammeter type of indicator in the station. Only 3 of the structures are equipped with this signal system, namely, the 2 on the main channel and the 1 on the north side of Oregon Slough. Fig. 6 is a diagram of this signal system.

EMERGENCY OIL SUPPLY

In case of damage to the cable (as for instance by a ship's anchor) which results in an oil leak, considerable time must elapse before the cable can be raised and the damage repaired. It was therefore considered advisable to provide emergency oil storage so that continuous oil flow can be maintained until repairs are effected. This emergency storage consists of simple drum type reservoirs, 2 of 50 gal capacity each for each terminal structure, with suitable piping and valve arrangement to connect these reservoirs with the cable oil system when needed. The valves are hand operated. These reservoirs are provided with tanks of nitrogen under pressure not normally in contact with oil, but with valve arrangements by which the oil in the tanks can be displaced by the nitrogen under emergency conditions. The contact of nitrogen with the oil for short periods of time is not considered especially objectionable, although contact for longer periods of time would be definitely deleterious. The nitrogen is supplied in ordinary high pressure cylinders fitted with special reducing valves. Safety valves are provided to limit the pressure of the oil when forced by the nitrogen gas from the emergency tanks to the cable oil system. The nitrogen is required to be extra dry and the cylinders are required to be dried out

before the nitrogen is introduced. Since it is necessary to avoid contact of the oil in the emergency tanks with air at all times during normal operation these tanks are serviced by small auxiliary reservoirs of the expansible cell type which maintain positive oil pressure in the main tanks at all times. This oil piping system is shown in Fig. 7.

Oil Pressure and Flow Characteristics

During installation great care was taken to maintain positive oil pressure at all times as a safeguard against accidental leakage and also during periods when cable ends were opened for terminal assembly. Under these conditions a predetermined value of oil flow must be maintained, just sufficient to prevent entrance of moisture or air. During operation the same problem exists and, in the case of submarine cable, the surrounding water pressure at different points of the profile must be considered.

Submarine cable in long lengths presents a more difficult oil feed problem than ordinary underground cable. The limiting conditions are, maintenance of positive oil pressure at middle of cable length during coldest winter weather, without exceeding a safe oil pressure on sheath at low water level under full load summer conditions. The armor gives some support to the sheath and the practise is never to exceed a pressure of 20 lb per sq in. at low water level. Water is more dense than oil. There is, approximately, 1 lb gain in head pressure of water for every 30 ft of depth, as compared with oil. The head pressure of oil is approximately $2^1/_2$ ft per lb.

The Columbia River crossing was particularly difficult because of the great difference (33 ft) between low and high water levels. The maximum depth in the middle of the channel at low water level is 30 ft, giving a depth of 66 ft at high water. After a careful study of conditions it was decided to use gravity feed reservoirs mounted at the same level

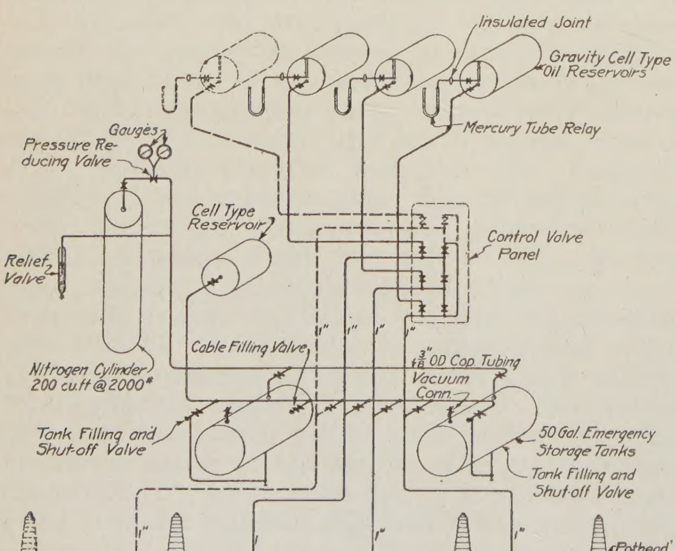


Fig. 7. Oil piping and arrangement for emergency oil supply

(44 ft above low water) at both ends and feeding toward middle of cable length. This represented an oil pressure of 18 lb per sq in. on the sheath at low water level and left only 1 or 2 lb margin of oil pressure over water pressure at middle of length when load is dropped in the winter at high water level. The margin is sufficient, however, since the assumed conditions are extreme and of only transient nature, the pressure drop in the cable core lasting for less than an hour after load is dropped.

These limiting conditions, and the need of utilizing all available oil pressure, did not allow the use of restrictors for limiting oil flow in hot weather in case of accident. In the winter such restriction is not needed but in the summer the reservoirs would empty at a fairly rapid rate in case of a "full open" accidental leak in the system.

This question was given careful study. Space does not allow inclusion of details. Briefly summarized, the conclusions are:

1. The regular switch signal or the oil level alarm relays will give warning immediately or soon after the accident, allowing an emergency crew to be on the scene within 1 or 2 hr.

2. The position of the failure, and other factors, will determine whether the reservoirs involved are exhausted of oil by that time. If not, the emergency oil supply is turned on and the nitrogen gas pressure adjusted (20 lb limit) to maintain an oil flow not greater than 6 gal per hr. This will entirely prevent entrance of water or air in the system and the flow can be maintained until the damage is located and repaired.

3. Even if one or more reservoirs are found exhausted the water will enter the cable core very slowly, if at all, and will have traveled only a short distance by the time the crew arrives. Emergency oil flow will then be adjusted as described, the oil leak located and the cable picked up, not at point of leakage, but 200 ft on each side. It will be cut under oil flow at these points and tested for moisture, repeating the operation in 100 ft steps if necessary. A length of replacement cable will then be spliced in.

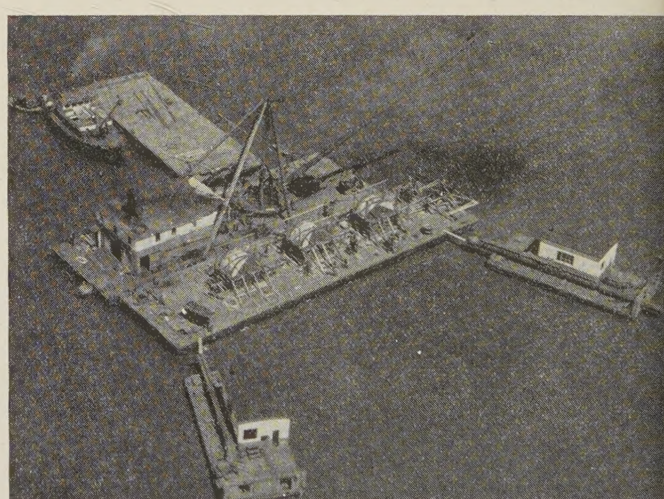


Fig. 8. Floating equipment used while laying cable

The repair joints, held in stock for such emergency use are of standard design successfully used in previous conduit installations with the exception that the spun copper casing is protected by a cylindrical armor box having bolted armor clamps at each end. The cable paper is stepped and the usual low loss varnished cambric tape used for reinforcement wrappings. The halved connector is of the double

ut-off plug design that has proved so successful in e past. The copper casing is 3 ft 8 in. long by 6 in. am. The armor box is 4 ft $2^1/_2$ in. long by 8 in. am.

istallation Procedure for the Columbia River Cable

THE importance of the 115-kv sub-arine cable crossing of the Columbia River, the usually great size of the reels of cable, and the fact at this was the first submarine installation of oil led cable to be made in this country, set a task of a w order for the construction forces, and created any unusual construction problems.

Several weeks before the installation was started, school was set up for the construction personnel d intensive training was carried out. This in-uded such work as making up pothead connec-ons by the use of short lengths of scrap cable. ndoubtedly it was this training together with very reful engineering of the construction work that abled the installation to be made without serious ishap.

ARGE EQUIPMENT

Equipment suitable for laying the long heavy ngths of submarine cable was difficult to assemble om a harbor the size of Portland's, and it was only ter considerable effort that necessary equipment a reasonable rental cost was obtained. This uipment as finally assembled consisted of a flat-ck barge, 400 ton capacity, 125 ft long, 32 ft wide, which the 3 cable reels for each crossing and con-ol equipment were placed. As auxiliary to the ble barge, a steam dipper dredge barge was utilized a derrick, and in addition there were 2 small soline donkey scows from the Port of Portland's edging equipment, a spare flat-deck barge for use spare deck space, and 2 small derrick tugs, one r use in changing anchor lines and anchors and one r emergency.

The main barge was arranged for laying the 3 bles at each crossing simultaneously, the reels being ounted in tandem for proper deck load distribution. ne 2 reels nearest the laying end, or stern of the rge, were raised sufficiently to allow the cable from e reel forward to pass underneath. Easy running llers were placed at such points as to eliminate all ssible friction. An overhanging timber structure s constructed at the stern of the main barge, with llers arranged for a minimum safe bending radius cable as it was fed overboard, and which spaced e cables 4 ft apart. The 2 flanges of each reel re equipped with friction band brakes, one used laying control and one for emergency.

Calculations for running lines and strains when ing the cable were made on the basis of maintain-g the main barge sidewise to river current, which the time of laying was approximately 7 miles per . A donkey scow was placed at bow and stern on

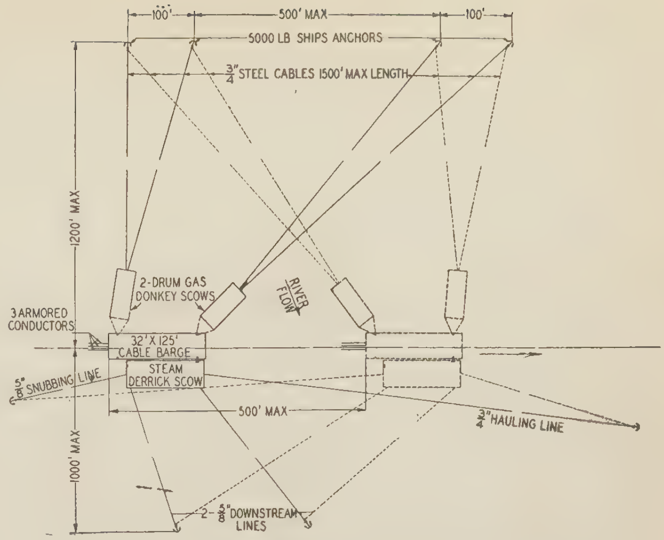


Fig. 9. Arrangement of floating equipment used for laying cable

the upstream side of the cable barge. Two steel lines, with large anchors attached from each of the donkey scows, were maintained upstream while laying and moved in successive steps across the river. The derrick barge was held alongside the main barge on the downstream side, with steel lines, also with anchors attached, extending from the donkey drums at bow and stern for control of movement across the river. These anchors were also moved as required. The derrick tugs mentioned were used for changing anchors and to clear lines of driftwood, trees, etc., which were quite heavy at this flood stage of the river. The general arrangement of the equipment is shown in Figs. 8 and 9.

Buzzer and bell signals were provided to each operation control point. One control was from the point where the cable went overboard, controlling slack and reel movement; another point controlled barge movement across river and the upstream anchor lines from the donkey scows. This control point was in turn controlled by telephone from the shore where men with transits were located for alinement of the cable.

LAYING THE CABLE

The shorter sections of cable across the Oregon Slough (see Figs. 1 and 2) were laid first, and on a rapidly rising river. The 3 shore ends, one at a time, were pulled over rollers located at frequent intervals, into terminal structure No. 4, by means of lines from derrick hoisting drums fastened to the armor pulling eyes at the cable ends. (The terminal structures are numbered consecutively from 1 to 4, beginning with the one farthest north, as indicated in Fig. 2.) Cables were then clamped in final position with necessary slack above terminal pedestals for terminal installation.

Temporary oil connections were made between the 3 cable ends and the 3 permanent oil pipings which had been installed with permanent oil reservoirs, emergency oil tanks, etc., previous to cable laying

operations. Oil supply to the cable was then made from the permanent oil supply apparatus, oil supply to the cable from the temporary pressure reservoirs shipped with the reels being closed off. Reserve supply of oil and the degasifying equipment were connected and made ready to provide against any possible emergency that might arise. After all connections were complete, short slacks were laid just outside terminal No. 4 and temporarily anchored, and the laying of the Oregon Slough crossing started. This laying to a point approximately 300 ft from terminal No. 3, where slack was to be dropped, took 5 hr. Slack, as engineered for this location, was laid out on the deck of the spare barge and lashed in place to cross timbers which were later raised with the derrick and the spare scow pulled from under the suspended cables. The suspended cables were then carefully lowered to the bottom of the river, later checked by a diver as to lay, and then the lashing cut allowing timbers to float to the surface of the river. The laying equipment was then moved to terminal No. 3, the shore end footage of the cable pulled from the reels and placed in the shape of a figure 8 on the deck of the spare barge. Reels were then removed from the main barge deck, ends of the 3 cables were pulled into terminal No. 3 and clamped into proper place. The 3 cables were then one at a time moved over toward the edge of the barge and carefully lowered overboard in final location alongside.

Laying of the 3 longer sections across the main channel was more difficult on account of the extreme high water and heavy current, but was accomplished in the same manner as the Oregon Slough crossing. Laying of these lengths was started from structure No. 1 on the Washington side of the river and laid to terminal No. 2. The crossing time of the river proper was approximately 14 hr, the following 2 days being used in disposing of slack at the outer edge of the 800 ft sand bar and working the barge equipment through the dredged channel to structure No. 2.

The same preparations were made at No. 1, where cable ends were first temporarily connected to the permanent oil reservoir system for any oil emergency condition, as were made at No. 4. These preparations were called into use shortly after the laying process started.

When about 1,000 ft from structure No. 1, the oil pipe connections between the inner end of the cable and the oil reservoirs contained within the reel body was sheared off on account of creepage movement of the inner layers of cable. The man handling the emergency oil apparatus at structure No. 1 immediately noticed a drop in oil pressure and, as instructed, supplied the emergency oil, maintaining the established pressure. Before the crossing of the main channel was completed the oil connections on the 2 remaining cables were also sheared off, also owing to the slippage of the inner layers of cable on the reel drum. The leaks thus developed could not be closed until sufficient cable was taken from the reels to allow access to the inner layer, and at one time it was problematical as to whether there was a sufficient supply of degasified oil available to maintain oil pressure on the cable until oil leakage from broken connections was stopped.

Terminal Installation

After the cable laying was completed, terminal pot head installation was immediately started at termina No. 3, the necessary oil flow from cut cable ends bein supplied from the permanent oil system through th temporary oil piping at terminal structure No. 4. N difficulty was experienced at any time during installa tion. The entire structure was temporarily covere with canvas to protect the working deck from rai and, in turn, each terminal location was inclosed wit a special tent during taping and terminal assemblin operations.

Terminals were next installed at terminal structur No. 4 with oil control for operations at this poin through the cable from the permanent oil system a No. 3. The same procedure in rotation was followe for the terminal installation at structures Nos. 2 an 1. In all terminal assembly operations, as well as a other times, telephone communication was main tained between all 4 structures. This communica tion between structures allowed very close regulatio of required oil flow and pressure during termina installation and also for the final adjustment an testing of the entire oil system.

Aside from the broken oil connection, no difficulty of any serious nature was experienced during the entire installation of cable and terminals.

Tests and Operation

As soon as the installation was completed a 3-phase 60-cycle short-circuit current heat run was made, temperatures, induced sheath and armor currents, oil volume changes, etc., being carefully measured. This heat run served a 2-fold purpose: it caused

Table I—Comparison of Calculated and Heat Run Data

Circulating Current* (Avg)		840 Amp Load	795 Amp Load
Sheath	Measured	12.1%	
	Calculated	11.3%	
Armor	Measured	90.3%	
	Calculated	93.2%	
Armor Temperatures (Max.)		**840 Amp Load**	**795 Amp Load**
Columbia River			
In air	Measured	28.0 deg C	
	Calculated	30.1 deg C	
Under water	Measured		24.1 deg C
Oregon Slough			
In air	Measured		30.5 deg C
	Calculated		29.7 deg C
Under water	Measured	25.4 deg C	
Oil Level in Reservoirs		**At 795 Amp Load**	**At No Load**
Columbia River	Measured	8.0 gal	4.5 gal
	Calculated	7.88 gal	4.2 gal
Oregon Slough	Measured	4.8 gal	2.8 gal
	Calculated	4.53 gal	3.1 gal
Ambient Temperatures		**Columbia River**	**Oregon Slough**
Water Ambient		15.0 deg C	16.0 deg C
Air Ambient		17.0 deg C	18.0 deg C

* Percentages given are in per cent of ampere load.

niform dispersion and absorption of any small nounts of impurities that might not have been cluded, and it furnished a final check on all theotical calculations. Table I gives a summary of iese calculations and the essential heat run data.

Operation of the cable under normal conditions since June 19, 1932, to date has been very satisfactory. Cable temperatures and oil level fluctuations have followed the calculated values very closely with varying load conditions.

urther Research in njuries From Electric Shock

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With approximately 2,500 persons suffering from electric shock annually in the United States, fatally in about 50 per cent of the cases, the problem presented is one of increasing importance. In recognition of this fact, intensive experimental work has been under way at The Johns Hopkins University for some time, supported by funds made available through the generosity of the Committee on Physiology of the Conference on Electric Shock. The accompanying article discusses the effects of injuries produced by surge discharges, and summarizes some of the more important conclusions previously published in ELECTRICAL ENGINEERING.

ACCIDENTS caused by electric iock in general and by contacts with low voltage rcuits in particular are increasing in number with ie increasing industrial and domestic use of elecical equipment. Case analyses have shown that dividuals between 15 and 30 years of age are ost likely to be the victims, perhaps owing to the eater carelessness of youth; and that more men e injured than women. Also, accidents have been und to be more common during the summer onths as a result of reduced protection by clothing, id the presence of perspiration which decreases ie skin resistance. To supplement the analytical udy of the case history of several hundred unrtunate human victims of electrical accidents, boratory experimental work has been carried on r some time by The Johns Hopkins University an effort to learn enough about the physiology volved to enable the determination of effective medial measures that will save human life.

ritten especially for ELECTRICAL ENGINEERING. *Not published in pamphlet m.*

In this laboratory work the injuries produced by electric currents have been studied through analyses of the effects of shocks upon living animals completely anesthetized. Animals differ widely in their ability to withstand electric shocks; dogs are killed by a relatively small current, while rats are much more resistant. The difference lies to a great extent in the behavior of the heart; the adult dog's heart readily is thrown into ventricular fibrillation by a small electric current, and does not recover from that condition spontaneously, whereas the ventricles of a rat's heart apparently do not fibrillate. By ventricular fibrillation is meant the failure of the ventricles of the heart to beat with a coordinated rhythm, the individual muscle fibers contract asynchronously instead.

While these wide variations in reaction make difficult the direct application to man of the results obtained experimentally from animals, the variabilities noted prove to be an aid rather than a hindrance to the progress of experimental work provided the proper animal is selected and the different reactions are kept well in mind. Thus, the authors have used the rat in their studies of the changes in the nervous system, and the dog in their studies of ventricular fibrillation; all animals of course thoroughly anesthetized throughout the entire experimental procedure. The essential features of this experimental work have been covered in previous issues of ELECTRICAL ENGINEERING:

1. "What Are Effects of Electric Shock?" June 1931, p. 406–10.
2. "Nerve Injuries From Electric Shock," December 1931, p. 929–32.
3. "Heart Injury From Electric Shock," April 1931, p. 242–4.

The present article includes results from some new work with an impulse generator, and summarizes a further analysis of previous work.

INJURIES FROM SURGE DISCHARGES

As the surge or impulse generator is used more and more widely in industry, there has arisen the question

of the danger to life of shocks received from it. In an attempt to obtain some indication of the correct answer to this question, several experiments have been conducted with a small impulse generator, the only resistance in the circuit being the body of the animal under test. Cathode oscillograms showed that under these conditions the current reached a value slightly in excess of 100 amp at 200,000 volts maximum. The steepness of the wave front is shown by the fact that the current reached its maximum value in $^1/_4$ microsecond, with the entire discharge completed in about $4^1/_4$ microseconds. With this apparatus several rats were tested with the results shown in Table I.

With group 1, a clip attached to the desired part of the body and extending several inches above the animal attracted the spark to a particular location. All of the 7 rats tested breathed spontaneously and were active immediately following the shock. The only evidence of abnormality was in the 2 that had received the discharge at the level of the shoulders; their sense of equilibrium was disturbed, and they rolled around in small circles for some 10 minutes, after which they were quite normal. It is evident that under these conditions little or no damage was produced by the surge discharge.

In the second group where 5 rats were suspended so that the surge traversed the entire length of the body, all died despite the use of artificial respiration. In only one of these rats was heartbeat noted following the shock; this rat made a few attempts to breathe, but died ultimately in spite of long continued efforts with artificial respiration. In this group of animals, rhythmic tremors of the striated musculature were observed most markedly in the hind legs.

Table I—Results of Surge Shocks on Rats

Group	Path of Surge	No.	Recovery	Breathing	Heart Beat	Resuscitation
1	Surge entered at:					
	Head	3	3	Normal	Normal	None needed
	Shoulders	3	3	Normal	Normal	None needed
	Rump	1	1	Normal	Normal	None needed
2	Tail to head	4	0	None	None detected	Failed
	Back of head to tail	1	0	Feeble	Feeble	Failed
3	Back of neck to tail	4	0	Feeble in 1; none in others	Feeble	Failed
4	Shoulders to tail	4	3	1 normal; others feeble	Normal	Not needed on 1; successful on 2
5	Middle of back to tail	4	3	Normal	Normal	Failed on the 1 requiring it
	Right fore leg to tail	3	2	1 normal; others feeble		Not needed on 1; 1 successful; 1 failure
	Left fore leg to tail	4	1	1 normal; others feeble to none		Not needed on 1; others failure
6	Back of neck to abdomen	4	1	Feeble to none	Feeble	Successful on 1

In Group 1 experiments the rats lay on the ground plate. All other experiments were made with the rats suspended.

The brain itself was not included in the path of the discharge applied to group 3, but the brain stem and the areas controlling the heart and respiration lay close to the electrode. In all 4 cases the injury to the heart proved fatal in spite of artificial respiration, and in spite of the fact that the heart damage was not so great as that noted where the discharge traversed the entire length of the body.

The 4 animals of group 4 were tested with the surge entering at the level of the shoulder and passing from the tail to the ground plate. Under these conditions, the portion of the brain that controls the heart and lungs did not lie in the direct path of the discharge. One animal breathed at once following the injury and recovered quickly. Another started to breathe spontaneously, but stopped and was saved by artificial respiration. The third also was resuscitated successfully, but the fourth died in spite of initial attempts to breathe. In all these animals their hearts beat strongly following the surge discharge. Marked tremors also were noted, and in one animal the hind legs were weak for an hour after the shock, subsequently becoming quite normal.

Following a surge discharge passing through the 4 animals of group 5 from the mid-thoracic region to the tail, all breathed spontaneously and the heart of each beat strongly following the shock. In one case, however, the breathing subsequently ceased and the animal could not be resuscitated. Also, several animals were tested by being suspended from one fore leg, the spark passing from the tail to the ground plate with the results as noted in the table.

In the tests on group 6 the discharge entered at the back of the neck and left in the mid-abdominal region. On the 4 animals tested in this manner, artificial respiration was used in every case, but with only one recovery. In all animals the heartbeat was weak following the discharge, but improved considerably during the next few minutes. Clonic movements followed the passage of the discharge.

As evidenced by earlier experimental work the heart of a rat is usually but little influenced by electric shock. This, however, is not true in the case of lightning discharge, under which condition the action of the rat's heart was in many cases definitely affected. Immediately following the discharge, either no heartbeat could be detected, or the heart was very feeble, but there was no evidence of ventricular fibrillation. Although in almost every case the discharge of the lightning generator used in these tests produced tremors in the musculature, there was but little evidence of the severe muscular contractions noticed in the earlier experiments with d-c and a-c circuits; in these impulse experiments the chests of the animals were expanded following the discharge.

These experiments with the surge generator again clearly emphasize the importance of the current path through the animal, and check the results already reported for the various current pathways. It is evident also that the amount of nerve tissue lying in the current path bears a direct relationship to the damage to the organism. In the tests, as the brain and nerve centers were eliminated from the current path, the chances of recovery became greater.

UMMARY OF EFFECTS PRODUCED BY ELECTRIC SHOCK

Some of the factors of greater importance in cases f electric shock will be summarized in the following aragraphs.

The effects of voltage as indicated by the experiient with rats showed clearly that low voltage a-c 1ocks are more deadly than d-c shocks of correoonding voltage; that d-c shocks on a 1,000-volt rcuit were more deadly than a-c shocks of correoonding voltage; that in either case the injury icreases with the increase in voltage.

he danger of contact with high voltage circuits is recognized widely, it the serious and far more prevalent hazard from contacts with low oltage a-c circuits in residences and factories as yet is not sufficiently idely understood for public safety. The danger of contact with w voltage circuits increases as the contact resistances of the body e lowered. When a person who is well grounded comes into ntact with a low voltage circuit through a defective electrical evice or otherwise, the value of the current may be sufficient to use death. The majority of such accidents occur in bathrooms, imp cellars, around water and gas piping, and other places where cal conditions reduce to a negligible value the contact resistance the body.

Then contact is made with a high voltage circuit, the contraction the muscles is so violent that often the victim is thrown clear, hereas it is difficult if not impossible for the victim to release his old in cases of low voltage shock because the muscular contraction steady rather than violent. When the body forms part of an ectric circuit it offers 2 resistances to the passage of current: e contact resistance, and the ohmic resistance of the body proper, at in the case of human beings amounts to approximately 200 ohms. he contact resistance offered by the calloused palm of a laborer ay be 100,000 ohms per sq cm, whereas with moisture present at same resistance may fall to 1,200 ohms or less per sq cm. nalyses of experimental data show that the contact resistance op is of the form of a voltage drop which is practically independent the current flowing.

In human beings electric currents of from 8 to)ma are quite painful; at 20ma the muscular ontraction is so great that the victim cannot release s hold on the circuit; a current of from 90 to 100ma considered dangerous.

human accidents only the voltage of the circuit usually can be termined, leaving in doubt the value of current flow through the dy. Sensitivity to electric current varies widely in different dividuals and various animals; in general the threshold of sensiity ranges between 0.5 and 2ma. Experiments reported upon other qualified investigators have demonstrated that in dogs a rrent of from 70 to 80ma flowing through the body produces ntricular fibrillation of the heart; that larger currents may cause fficient muscular contraction to inhibit all heart action. In these tter cases the heart usually resumes rhythmic beat when the rcuit is opened.

ot only is total current through the body of importance, but the rrent density also must be considered. In their laboratory periments, the authors found that a small animal could not cover from a given shock so readily as could a much larger animal. Perhaps this is one of the reasons for the belief that thin people are more susceptible to electric shocks than are large individuals.

The duration of the contact with electric circuits is of extreme importance in determining whether or not the victim will survive. In general, the hope of successful resuscitation dwindles as the time of contact and the voltage of the shock is increased.

Usually in cases of human accidents but few data are available to reveal the length of time the current flowed through the body of the victim. Fortunately, because of the violent muscular contraction when contact is made with high voltage circuits, the shock is usually of short duration. In cases of low voltage shock, however, the person may be held in contact with a circuit for an appreciable time. Laboratory experiments with animals have borne out the vital importance of the time factor.

Human beings sometimes retain full consciousness while in contact with an electric circuit and are able to call for help, whereas others are rendered unconscious at once.

If the victim recovers, consciousness may return after a few seconds or minutes, and usually the victim is able to return immediately to his work provided the injuries inflicted by the current are not severe. In some instances, however, the unconscious state passes into a deep coma which in turn is interrupted by violent convulsions terminating in death. There are on record several accidents in which unconsciousness followed a shock between 2 fingers of the same hand, or 2 points on the same leg. In such accidents no current flowed through the central nervous system, and the resulting unconsciousness must have been due to the sudden shock and the resulting vasomotor reactions.

That shocks may cause a "block" in the nervous system that will inhibit respiration has been demonstrated conclusively. If artificial respiration is applied promptly and continued for a sufficient time the respiratory nerve center may have opportunity for successful recovery.

Extensive laboratory experiments substantiate the value of prompt and long sustained artificial respiration. In the microscopic examination of the nerve tissues of test animals the injury to the nerve structure was demonstrated clearly. In those animals which could not be induced to breathe following the shock the cell damage was most marked; in some instances the severity of the nerve cell injury was incompatible with life.

Hemorrhages have been found in the spinal cords of many of the rats subjected to laboratory shocks, but injuries of this type are not found in the case of human accidents.

In several animals, however, hemorrhages were found both in the substance of the medulla oblongata and filling the fourth ventricle of the brain; similar hemorrhages are common in legal human electrocutions. Apparent hemorrhages in the lungs have been noted in the case of some human accidents, a condition noted also in the laboratory experiments. Excepting only those which distended the fourth ventricle pressing on the respiratory center and those occurring in the spinal cord, the hemorrhages found in the

Table II—Effects of Voltage

Voltage	Number Tested	Duration of Shock Sec	Current Milliamp	Per Cent Receiving Artificial Respiration	Per Cent Paralyzed	Per Cent Died	Per Cent Immediate Recovery	Average Resistance Ohms
A-C—110	11	10–30	25–48	90	9	27	64	3,091
D-C—110	33	5–60	28–47	30	3	12	85	2,685
A-C—220	28	5–14	80–200	93	38	34	28	1,890
D-C—220	19	5–30	100–200	74	5	42	53	1,635
A-C—500	26	1–4	240–490	73	50	12	38	1,425
D-C—500	37	1–4	280–640	89	5	46	49	1,385
A-C—1,000	28	1–4	650–1,200	85	39	32	29	1,140
D-C—1,000	31	1/10–1	600–1,100	97	13	58	29	1,365

brains of the rats seldom were responsible for the death of the animals involved.

Convulsions are recorded occasionally as following an electric shock in human accidents, a phenomenon observed also in several of the experimental animals.

The animals so affected were found to be hypersensitive to all sensory stimuli after the shock. In a few cases there was evidence of disturbance to the vestibular mechanism, as shown by the animals walking or running in circles.

The human heart seldom recovers spontaneously from the state of ventricular fibrillation. Some observers of electrical accidents believe that the majority of deaths are caused by this abnormality. Therefore the action of electric current upon the heart is of the greatest importance.

As yet, no specific method has been developed for the recovery of the fibrillating heart in human beings. Nevertheless, in accredited experimental work carried on by other investigators, it has been demonstrated that the fibrillation in a dog's heart can be stopped by the injection of a potassium chloride solution into the carotid arteries. The injection of this solution inhibits all contraction of the heart musculature. The solution is then washed out with physiological saline solution and the heart resumes its normal rhythm.

Permanent disability following electric shock is shown by only a very small percentage of the individuals who have recovered from an electric injury.

Extensive burns following actual contact may be slow in healing, and nerve ends sometimes get caught in the scar tissues thus producing a lasting irritation. In a few instances cataracts of the eyes have been found, and in others, instability of the nervous system for an appreciable time following the shock has been noted. How much of this is caused by actual damage to the nerve cells, and how much should be classed as neurosis, is difficult to say. According to reports published in Germany in 1931, there seems to be the possibility that muscular atrophy may follow electrical accidents either soon or after several months' delay. It is reported that this effect usually is preceded by pain and abnormal sensations in the extremity, and accompanied by vascular disturbances. These data are interesting, but they must be examined critically. In the literature of England and the United States no similar cases of atrophies following electric shock have been found. It is of particular importance, therefore, that these late effects be watched for carefully in the future.

Causes of Death

It is recognized that the heart and the respiratory center in the brain are particularly susceptible to injury by electric currents. From the authors' experimental work with animals and from their analyses of reports of human accidents it is evident that death as an ultimate result of electric shock may occur from several different direct causes:

By asphyxiation caused by the prolonged muscular contraction.

By ventricular fibrillation of the heart, usually believed to be inducted by low voltage shocks.

By destruction of nerve cells in the respiratory center of the brain.

By excessive increase in body temperature as a result of the Joule effect of the shock current.

By severe burns or other resulting complications.

Competent authorities stress the fact that in electrical accidents death often is *only apparent*. Artificial respiration should be begun *immediately* following an accident and continued until the patient recovers or until the cessation of life as an actuality is evident by the onset of *rigor mortis*. Accredited reports list many successful resuscitations following the application of the Schaefer prone pressure method of artificial respiration, in one case success following an 8-hr. effort.

Conductor Vibration on Transmission Lines—III

Field tests made in California on a double circuit tower line comprising one aluminum and one copper circuit show that these different types of conductors vibrate under approximately the same conditions and at about the same frequencies, aluminum vibrating with the greater amplitude.

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San Francisco, Calif.

A CAREFUL STUDY of the vibration problem on the lines of the Pacific Gas and Electric Company (Calif.) was undertaken after trouble had developed in some of the early damper designs of the Stockbridge type. This trouble was due to fatigue of the supporting messenger strand. Life tests made on these early assemblies soon revealed the necessity of substituting high strength steel strand in place of the ordinary guy strand or Siemens-Martin grade. This substitution changed the characteristics of the damper slightly, but later tests proved that the dampers still were effective. The life tests were made on the damper assemblies using a vibration machine similar to that shown in the Monroe-Templin paper (Fig. 7, p. 487, Elec. Engg., July 1932). The revised damper design using the high strength steel was given a life test of more than 100,000,000 cycles without failure. The failures in the supporting strand occurred not at the center clamp or point of maximum stress, but where the cable enters the weight; a point where the strand is subjected to a reversal of stress.

Mr. Monroe and Mr. Templin seem to favor 2 dampers per wire per span wherever possible. I prefer using 4 dampers for any line conductor of 1-in. diam or larger. These 4 dampers should have their spacing so staggered that not more than one damper would be located at a node point for any of the frequencies most often experienced. This method as a rule permits 3 dampers to be so located that they may be fairly effective as dampers. A damper has its greatest efficiency when located at the center of a loop, and the Stockbridge damper is most efficient when the natural period of the damper is approximately that of the vibrating cable. To make a more careful study of damper spacing a test span was

Full text of a discussion submitted concerning the Monroe and Templin paper "Vibration of Overhead Transmission Lines" published in the July and August issues of Electrical Engineering and previously presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932. *Not published in pamphlet form.*

ected and this span was vibrated mechanically at om 4 to 22 cycles per second. After studying the mper spacing on this short span the test equipment as transferred to the field, and spans actually in rvice on line towers were vibrated to obtain data ainst which the laboratory results might be ecked. These tests all seemed to indicate that the e of 4 dampers with staggered spacing was much ore satisfactory than the use of only 2 dampers. ith modern dampers of the Stockbridge type operly designed and located, I believe vibration n be controlled so effectively that no damage will done to the conductor.

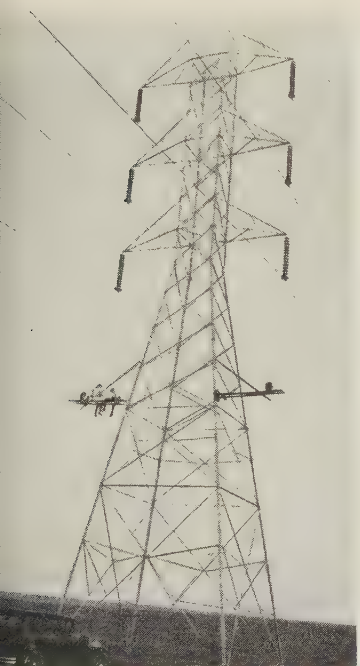

Fig. 1. Mounting of recorders on a tower line having one aluminum and one copper circuit

Records were taken while the lines were in operation (the aluminum line at 165 kv and the copper line at 220 kv) by placing the instruments on platforms 20 ft beneath the lower conductors to which the recorder actuators were connected at points about 6 ft from the suspension clamps by means of special cords. Conductors: A.C.S.R., 795,000 cir mil, 1.093-in. diam; copper, 509,400 cir mil, 4CS hollow core, 1-in. diam

Most of the testing was done on an aluminum line consisting of 3 795,000-cir-mil steel core aluminum cables having a conductivity equal to 500,000-cir-mil copper, and strung as one circuit on a double circuit 220-kv tower line. On the opposite sides of the same towers there are 3 hollow core copper cables of 1-in. diam having a section of 509,400 cir mil. The 2 sets of cables are parallel, with only 27-ft horizontal separation; they have the same ground clearance and hence have the same sag, and are supported in the same manner. Therefore, all spans are alike. This line represents almost ideal conditions for the checking of relative vibration on these 2 types of conductors.

A study of the relative vibration of the 2 types of conductor was undertaken and vibration recording equipment to take simultaneous records was installed and arranged as shown in Fig. 1. Observations were made for several weeks at a time when conditions were rather favorable for vibration. The data from the field tests are shown clearly in Fig. 2, where it may be observed that the copper and aluminum cables vibrated at approximately the same time. Loop lengths were observed to be of the same magnitude and the conductors vibrated at approximately the same frequency, but the amplitude of vibration of the copper conductors was less, as may be noted.

There is one other point to which attention should be called in connection with the vibration of transmission line conductors. Vibration in general occurs during the night hours, late in the evening, or quite early in the morning; the wires seldom vibrate during the usual working hours of the day. This point has led some engineers to believe their lines free from vibration.

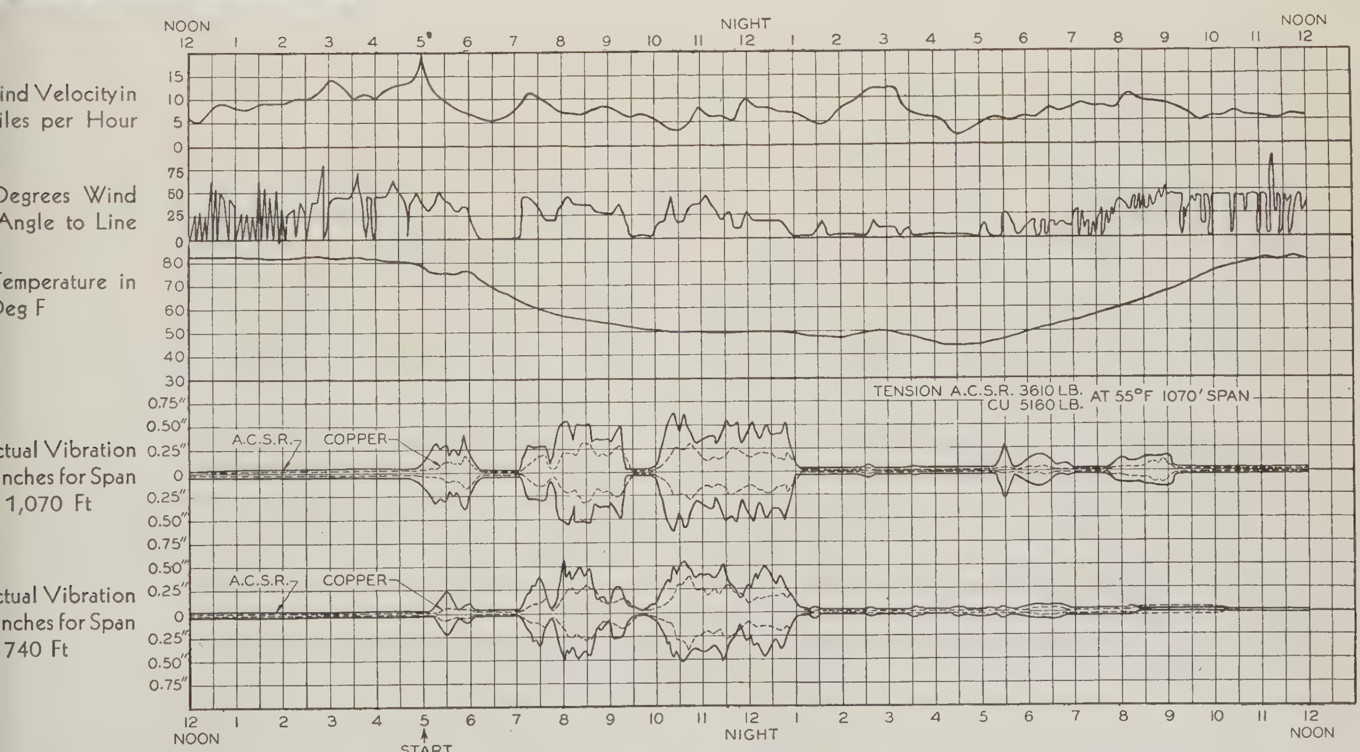

Fig. 2. Simultaneous records of wind velocity and direction, air temperature, and the vibrations arising from these conditions in parallel copper and aluminum conductors. Smoked chart records were taken through a 24-hr period beginning at 5 p.m., May 8, 1932

Adult Technical Education in Metropolitan Areas

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A plea for careful study of the advantages to be gained through properly coordinated efforts in, and facilities for, intermediate technical education and postgraduate work.

PROFESSIONAL progress of our engineering societies has been and always will be influenced by the education of their members. Whether that education is recognized by professional degrees or is secured through pursuit of non-academic technical instruction is unimportant. It is, however, of interest and importance to know about the agencies contributing to the training of the potential professional engineering group, and how they may be made more effective in meeting the demands of this group.

In recent years through the investigation made by the Society for the Promotion of Engineering Education, attention has been directed to the entire system of engineering education. During the past year the educational committee of the Institute has given consideration to many of the problems brought forth by these and other studies. Affecting all of these problems is a general educational movement that for some time has been gaining in importance, but which only recently received organized recognition in the form of "adult education." It is the purpose of this paper to point out some of the possibilities in the development of adult education as they affect technical education and the providing of technical employees for industry.

Supply of Engineering Graduates

In recent years, the employment of college graduates has been of no small concern. Figure 1 shows clearly what has taken place from the days of intense competition, 1924–29, up to the present time, when satisfactory employment is almost impossible. While this situation is of concern today, it is quite possible that the next 5 years will see a recurrence of the conditions that existed 5 years ago, for it is apparent that business conditions affect freshmen enrolments, with graduations reflecting these conditions 4 years later.

Whatever the situation may be, it is important to have some idea of the long term needs for engineering graduates as compared with the supply. An attempt in this direction was made by the National Industrial Conference Board a few years ago in a study of typical industries that seemed to show that 40,000 technically trained men could be absorbed by industry each year. This does not mean only professional engineering graduates, but includes all men with technical training. The recent study of technical institutes seems to show that from 40,000 to 50,000 men with intermediate training can be absorbed in normal times by industry, trade, and technical services. It is further stated that the ratio of engineering graduates to this group is approximately 1 to 3, which fact indicates that the present supply of engineering graduates should nearly meet the normal needs.

The normal demands for men with training perhaps equivalent to only half that of the 4-year undergraduate course do not seem to be met by schools established for that definite purpose, for the supply from this source is only approximately 1,500 a year. However, there are 15,000 non-graduates of engineering colleges each year who drop out of school and go to work in industry, not all of whom, by any means, lack adaptability to technical pursuits. Also, there are thousands of high school and vocational school graduates who, after entering industry directly from such schools, continue study in evening technical schools.

In 1930, out of 111 engineering colleges, 22 reported a total of 16,000 students enrolled in evening

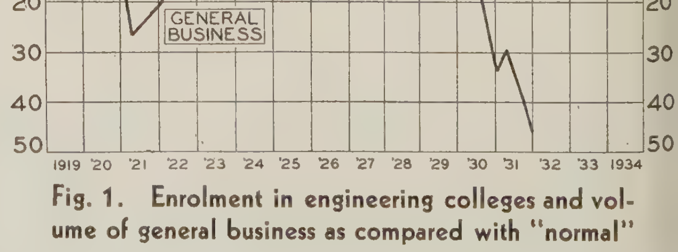

Fig. 1. Enrolment in engineering colleges and volume of general business as compared with "normal"

courses, of which number about half were studying for engineering degrees, while 1,760, or 11 per cent, were receiving credit toward advanced degrees. Among the evening school students are many of the group of non-college graduates who have dropped out of day school. Although records indicate that only a few of them ever will receive engineering

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Based upon a paper presented informally at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932. *Not published in pamphlet form.*

degrees, a sufficient number of them are adaptable to technical careers and meet a substantial part of the requirements of industry.

Importance of Evening Educational Facilities

It is a characteristic of our 145 undergraduate engineering schools that many of them are located in relatively small communities, and that upon graduation their students migrate to the larger metropolitan and industrial areas. It is in these areas that the greatest possibilities are offered for the development of postgraduate instruction as well as other forms of engineering education, such as co-operative courses and intermediate technical instruction.

In the 1930 Census the United States Department of Commerce called attention to 95 metropolitan districts which it had established upon the basis of each having an aggregate population of 100,000 or more, and containing one or more central cities of 50,000 or more inhabitants. (Fig. 2.) In these districts is approximately 44 per cent of the total population of the United States. It is safe to say that more than 3/4 of all engineering graduates are located in these areas. The question naturally arises as to the educational facilities, activities, and future needs of these areas. In the development of plans it would seem fairly fundamental to make a scrutinizing study of each district, bearing in mind the achievement of the fundamental objective of providing variety in training along with opportunity for professional development.

The successful development of facilities appropriate to each area, although depending largely upon the educational leaders of established institutions, will likewise need the support and cooperation of industries; at least to the extent of their making known the nature of their employment and training requirements, and stimulating their employees to take advantage of such educational courses as may exist. It would seem that the establishment of a well balanced program should include:

1. A study of the nature of the industries and occupations in the area considered.
2. Promotion of an effective system of vocational training in addition to academic high school education.
3. Establishment, where justified, of appropriate facilities for intermediate technical instruction of both the technical high school and the institute type.
4. Development of existing professional engineering schools.

The importance of a well balanced program is recognized, of course, but in only a few instances has any particular attention been given to the technological aspects of it.

New York Studies

In New York 2 significant studies are in progress: one conducted by the Board of Education has to do with vocational education; the other is entirely independent, and is concerned primarily with evening technical education. The latter study is being conducted by the committee on commercial education of the Chamber of Commerce of the State of New York. A full report of this survey will be published in the fall of this year and should prove of interest to educators and industrialists. The main objective of the report is to ascertain the facts concerning the present facilities for adult technical education in the New York industrial area, and the purposes, results, and needs for education in this field.

New York Educational Facilities

The 1930 census established the New York industrial area as including a population of 10,901,424, or slightly less than 9 per cent of the total population

Fig. 2. The 95 "metropolitan" districts listed by the U.S. Department of Commerce based upon the 1930 census

of the country. For the purposes of the Chamber of Commerce survey, the area considered is approximately the same as this district and includes 6 counties in New York and 6 counties in northeastern New Jersey.

In this area the schools and colleges giving some form of education associated with or preliminary to technical instruction include 12 engineering colleges and technical institutes of which 9 offer evening instruction, 4 evening schools of the Y.M.C.A. offering technical instruction, 25 public evening trade and vocational schools, and 32 private evening trade and vocational schools. The 9 engineering schools or institutes offering evening instruction are the agencies for primary consideration.

Enrolment in Evening Technical Courses

In the 9 colleges and technical institutes offering evening courses approximately 10,000 students are enrolled; another 25,000 are enrolled in either trade or vocational schools. The distribution of enrolments by courses is shown in Table I, and may be taken as an indication of the relative demand.

Of special interest is the group of students enrolled in the 9 colleges and technical institutes. The 13,660 course enrolments studied covered only 8,000 of the 10,000 students enrolled, but were so taken as to be representative of the group. An effort was made in the survey to study the type of students

enrolled, and their industrial employment. About $^2/_3$ of the students were found to be between 19 and 26 years of age, although it is significant also that many were men occupying substantial positions in industry.

A study of the educational preparation of these students indicates that about 80 per cent had a high school education or better, about 33 per cent had gone to college, whereas less than 10 per cent were college graduates. This latter figure, while small in comparison with the entire group, represents from 800 to 1,000 college graduates, and is evidence of considerable interest in further education.

Graduate Study

Up to the present school year the only evening colleges offering recognized degree-granting courses in engineering were New York University, The Polytechnic Institute of Brooklyn, and the College of the City of New York. These courses require from 6 to 10 years for completion. Only one of these

Table I—Summary of Enrolments in Technical Courses of Evening Schools in New York Industrial Area

				New Jersey Public Schools		New York Public Schools		
Subjects	Colleges and Technical Institutes	Y.M.C.A. Schools	Private Trade or Vocational Schools	Vocational or Trade	High and Elementary With Indust. Subj.	Vocational or Trade	High and Elementary With Indust. Subj.	Total
Architecture								
Arch. Engg.	11							11
Bldg. Eqmt. & Constr.	221							221
Design	218							218
Drawing & Drafting	1,760	13	30	404	35	400	55	2,697
Hist. of Arch.	69							69
Plan Reading & Est.	363	7		57	24	249		700
Total	2,642	20	30	461	59	649	55	3,916
Engineering								
Aeronaut. Engg.	6							6
Chem. Engg.	300							300
Civil Engg.	1,263							1,263
Drawing & Drafting	219							219
Elec. Engg.	1,600							1 600
Heat. & Vent. Engg.	20							20
Indust. Engg.	80							80
Mech. Engg.	1,565							1,565
Prep. & Elem.			8					8
Total	5,053		8					5,061
Mathematics								
Elementary Math	1 778	75	2	228	57	413		2,553
Advanced Math	1,275							1,275
Total	3,053	75	2	228	57	413		3,828
Physical Sciences								
Chemistry	765	19		133		47		964
Geology	17							17
Metallurgy	34							34
Mineralogy	3							3
Physics	1,203	16				74		1,293
Total	2,022	35		133		121		2,311
Trades & Voc.								
Trade & Voc. Subj.	1,275	531	2,016	4,428	777	9,635	1,463	20,125
Grand Total	14,045	661	2,056	5,250	893	10,818	1,518	35,241

schools, The Polytechnic Institute of Brooklyn, offers degree-granting postgraduate courses. The development of this work by the Polytechnic Institute is of considerable importance, for many college graduates yearly find employment in the New York area and look for opportunity for further study there. Prior to 1925 only a few miscellaneous courses of the graduate level were offered at Brooklyn Polytechnic Institute.

The development of evening graduate study doubtless will be followed with considerable interest, for it suggests an effective means for the engineer to continue his education after graduation, and offers also a solution to the economic problem of financing graduate study after a considerable investment already has been made for undergraduate work.

Nature of New York Industries

In a metropolis such as New York the question of the adequacy of local technical education is advanced periodically, either by civic associations, educational bodies, newspapers, or other interested groups. A suitable approach to the answer to questions relating to demand, utilization, and encouragement of technical graduates would seem to be a systematic investigation of the industries in each of the large metropolitan areas, with the objective of establishing or developing such educational agencies as seem necessary to meet industrial requirements.

In most industrial concerns the most important requirement is to impart to the individual sufficient technological information about the process he handles to enable him to conduct his work intelligently. Because such training usually takes the form of single process instruction to the individual, it is not concerned with education of college or professional grade. It is a serious question, however, as to how much technological instruction can and should be given technical workers and minor supervisors. Since technical instruction is an instrument of industry and its place and usefulness is confined almost entirely to industry, there would seem to be a field in technical education which should aim to supply such scientific courses as would aid the individual to a better understanding of technical processes. What these subjects are must evolve largely from a study of industry.

New York is commonly looked upon as an area of large industrial establishments. However, the fact is that aside from about 3 dozen large manufacturing companies employing on an average 2,233 employees, and a group of 1,700 companies of intermediate size employing on an average 292 employees, each of the remaining 34,000 companies employ less than 100 individuals, and average only 16 per establishment. The large manufacturing companies employ only $6^1/_2$ per cent of the total; and the small companies 50 per cent. These facts would seem to indicate considerable difficulty in training substantial numbers within industry, and almost a necessity for some outside agency to provide technological training either prior to the individual's employment or through evening education for those employed.

In connection with New York evening school en-
olments it is of interest to observe that fully 3 imes as many students are enrolled from the ser-
ice industry group as from the manufacturing in-
lustry, although the latter employees number al-
nost 50 per cent more than service industry em-
loyees.

The service industries include public utilities, ity employees, architects and consulting engineers, uilding industries, cleaning establishments, and arages. The public utilities are large, well estab-
ished companies with training requirements for the nost part cared for internally. Their employees, owever, in comparison with those of the manufac-
uring group, seem to show more interest in profes-
ional technical courses, as do also the employees of he city and professional engineering establishments. This manufacturing group looks more to the pro-
essional schools of engineering for recruiting its uture technical personnel.

)EMAND AND NEED FOR TECHNICAL EDUCATION

From preliminary observation it would seem that here is need for variety in technical education; nd that the development of adult or evening in-
truction in metropolitan areas offers a partial olution in meeting the need not only for the inter-
nediate type of training, but also for the graduate nstruction of the engineer. This is a subject of nterest to all of us. However, the demand as nanifested by the interest of employees in industry s not so evident. This may be due to any or all of he following causes:

. Facilities are not always conveniently available.

. The proper incentive has not always been given through definite ducational and training policies on the part of management.

. Unit courses are not developed sufficiently for maximum benefit the employee.

. Anything less than the conventional 4-year college course seems ot quite reputable nor acceptable to those to be trained, perhaps ecause of the feeling that such training might limit their life achieve-
nent to specific fields and levels less remunerative and esteemed han those attained through the 4-year college course.

From an industrial point of view, there is little r no justification for the latter conclusion, for in he industrial and service group in the New York rea alone, there will be in the next 10 years at east 150,000 positions of suitable responsibility vailable. How many of these should be occupied y technical graduates is not known, but it is safe o say that the majority of them will be filled by nen of less than college graduate training, whose hances would be greatly improved if they were in raining today.

This article is presented for the purpose of calling o attention a possibility which if followed to a ogical conclusion, holds promise not only of im-
roving the professional status of the engineer, but lso of causing a more sane adjustment of technical vorkers to acceptable vocations. In its fundamen-
als it means a study of the world's work and the cceptance of the philosophy of the concurrent ursuit of educational improvement and gainful ccupation.

Double Conductors for Transmission Lines

Two overhead conductors a few inches apart used for each phase of a transmission line circuit reduce the reactance 20 per cent or more, thus, in many cases, increasing the power rating of the line. Also current carrying capacity and corona voltage limits are increased. However, costs with this type of construction are higher than with one larger conductor per phase. In addition to describing the advantages and disadvantages of double conductor lines, formulas are given in this article for the calculation of the electrical characteristics.

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DOUBLE conductors transmission lines, that is, lines employing 2 overhead conductors for each phase instead of the usual one for each phase, present a number of advantages. These advantages must be balanced against the extra cost due to mechanical features, including hangers, increased cost of stringing and additional wind and ice load. The construction is the same as in the usual transmission line except that a second conductor is run a few inches below the first by metallic hangers, similar to those used in electric railway catenaries. The 2 conductors therefore are electrically in parallel and form one effective conductor of large cross-section without increasing the number of insulators or cross-arms.

REACTANCE

An overhead double conductor line has approximately 20 per cent less reactance than a single conductor line of the same weight of conducting metal. In many usual cases, especially where there is not complete control of the voltage by synchronous condensers, the reactance is the most important item in determining the power rating of the line, for both the voltage drop and the stability limit of the load

Based upon "Double Conductors for Transmission Lines" (32-99) presented at the A.I.E.E. North Eastern District meeting, Providence, R. I., May 4-7, 1932.

depend principally on the reactance. Therefore, in many instances, without increasing the weight of conductor metal, a line can be built for about one-fifth greater power rating at very little increase in cost where ice load is absent, by using double conductor construction. This is particularly advantageous where the cost of the right-of-way is large, and is is desirable to transmit as much power per circuit as possible.

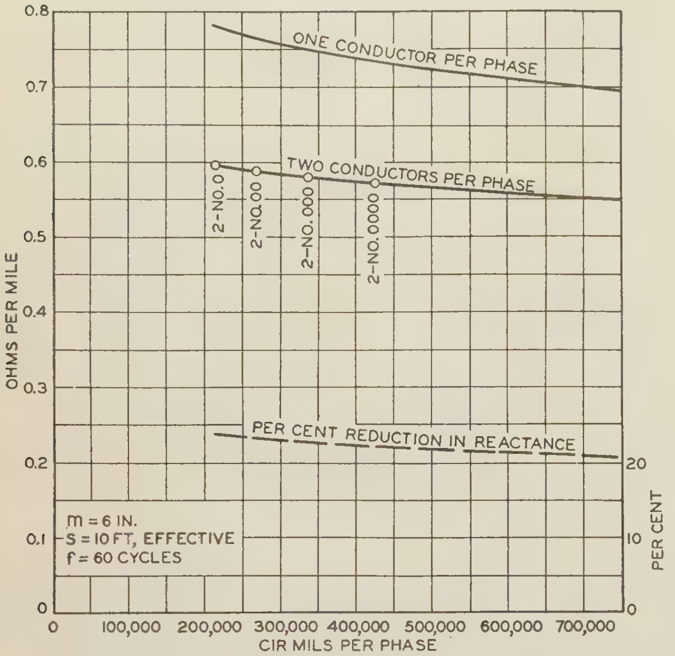

Fig. 1. Comparison of reactance of single and double lines for different conductor sizes

In Fig. 1 is shown graphically the reduction in reactance, amounting to approximately 20 per cent on practical lines, obtained by using double conductor construction. The formula for the reactance of a double conductor line, suitable for usual overhead spacings and for round wire, is

$$\text{Reactance} = \pi f 10^{-6}\left(80.5 + 741 \log_{10}\frac{s^2}{m\rho}\right) \text{ ohms per mile} \qquad (1)$$

where

f = frequency
s = geometric mean radius of the spacings between the phases
m = separation of the 2 wires per phase
ρ = radius of the conductors

If the conductor is a 7-strand cable of diam 2ρ, the figure 80.5 is changed to 103.3 and if there are 19 strands, the figure becomes 89.3. (See reference 9, p. 127, for other numbers of strands.)

Fig. 1 is drawn for copper conductors. It may be noted that hollow conductors and aluminum conductors of equivalent resistance have from 5 to 7 per cent less reactance than the values shown for single conductors in Fig. 1. The 2 small conductors of the double conductor line may be of aluminum if desired.

The effect of changing the distance between the 2 wires of the same phase, in a double conductor line, is shown in Fig. 2. It is seen that for spacings larger than 6 in. there is little further improvement. Accordingly the discussions in this paper for the most part are based on a value of 6 in. Curves for other conductor sizes and for other spacings between phases are very much the same as the curves of Fig. 2.

Resistance

Another limit to the power rating of a transmission line is the cost of resistance losses. The greatest advantage of double conductor construction in this connection is in the case of a line already built, which has higher resistance than desired and which has some mechanical margin of safety. It is possible to add a second conductor and cut the resistance in half without the necessity of taking down or scrapping the old conductor. In other words it is possible to make the reduction in resistance with only one-half as much new conductor metal as would be needed if single large-size conductors were installed. It is, of course, necessary that the line be strong enough to stand the extra weight including wind and ice on the second conductor. The proposition to add to the conductor metal of existing lines may be attractive at a time when the cost of conductors per pound is low.

For new transmission lines the difference in resistance between single and double conductor lines of a given weight of conductor metal is due to skin effect. The amount of the difference is shown in Fig. 3. It is seen to be a matter of minor importance with over-

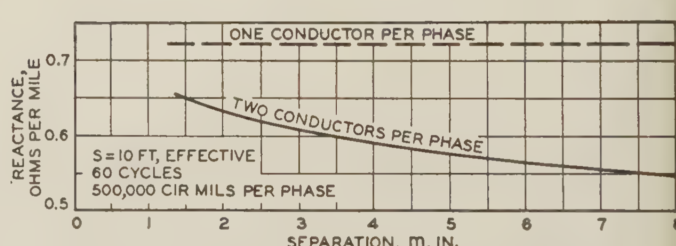

Fig. 2. Change of reactance with separation of paralleled conductors

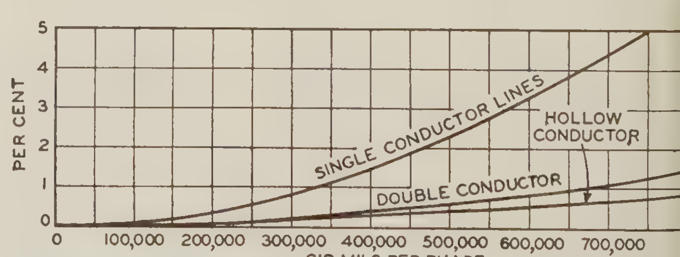

Fig. 3. Increase in resistance due to skin effect at 60 cycles

head conductors of usual sizes. For obtaining values of skin effect of hollow conductors, see reference 1.

Heating of Conductors

In the preceding 2 paragraphs the cost of resistance losses was considered as a limitation to the allowable power load of a line. With some short lines, and notably with many tie-lines, voltage drop and the

st of resistance losses are not serious limitations to e allowable load, and heating of the overhead con-ıctors is the practical limit encountered. In many ses, twice the normal load must be carried by one rcuit as an emergency condition. Annealing of the ırd-drawn copper and oxidation of joints in con-ıctors are reasons for keeping the conductor tem-erature down.

Tie lines have been built with very heavy overhead onductors for the purpose of avoiding overheating of ıe conductors. A 132-kv, 30-mile tie line from hicago, Ill., to Waukegan has been built with 50,000-cir-mil hollow copper conductors. It is ated in reference 6 that the main condition in esigning the line was the heavy current to be carried.

The curves of Fig. 4 have been drawn from the ble of current ratings published in reference 3, p. 56, for bare conductors, outdoor service, and 40 deg C se. It is seen that double conductor construction

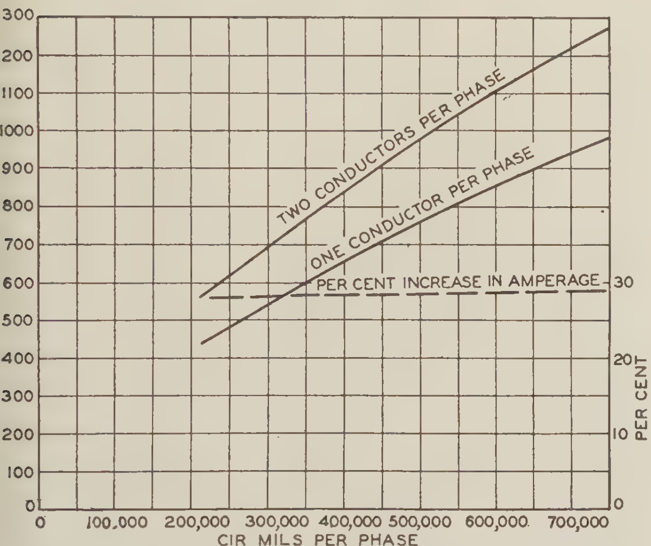

Fig. 4. Current carrying capacity of bare conductors for outdoor service with 40 deg C temperature rise

ıcreases the current carrying capacity nearly 30 per ent for a given weight of conductor metal. This is ecause the 2 small conductors have more surface ıan the single large conductor. If current ratings om the table for indoor service were used, the per-entage difference between single and double con-uctor construction would be nearly the same. follow copper conductors, because of their large iameter, show an increased current carrying capac-y over corresponding standard cables, though the ıcrease is usually a small percentage. Aluminum onductors also have larger diameter and therefore reater current carrying capacity than standard opper cables of the same resistance.

APACITANCE

As is shown by Fig. 5, the capacitance of an over-ead double conductor line is 20 per cent or more reater than that of a single conductor line of the ame weight of conductor metal. This is an advan-ge in the case of power networks in well-settled parts of the country where the loads and generating stations are scattered to some extent throughout the network. In such networks it is a matter of experience that synchronous condensers are used almost entirely with strong field currents, and very few with lagging power factor load and weak field currents. Consequently, an increase in line capacitance of 20

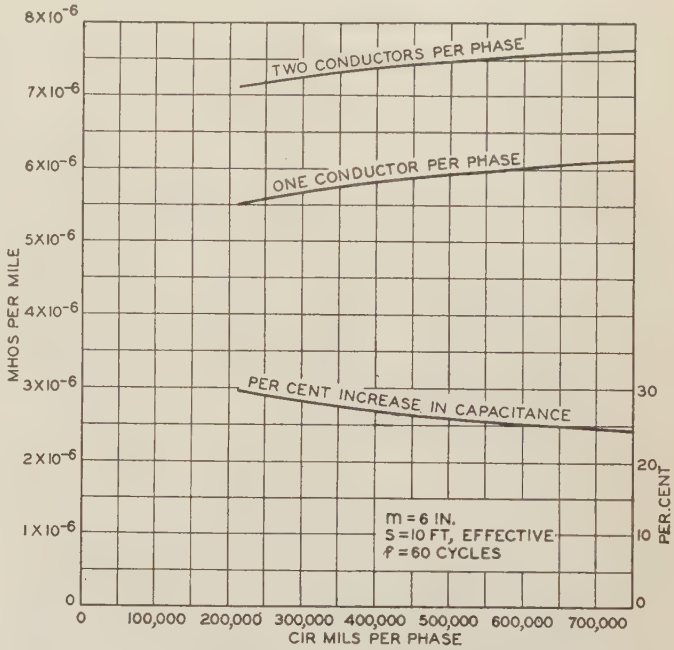

Fig. 5. Comparison of capacitive susceptance of single and double conductor lines

per cent means a saving of a definite amount of synchronous condenser capacity which would otherwise need to be installed.

In other cases, where transmission lines are very long and the loads are widely separated from the generators, special attention is required to handle the line capacitance current. A sufficient number of generators must be kept always connected to the system, so that the no load current is not an overload for them and so that the field current at rated voltage and leading power factor load does not become so small as to endanger the stability of the system. While these matters require attention, yet they seldom involve expense, particularly in the case of water power systems where they are most likely to be noticeable, for there are practically always plenty of generators available. Accordingly even in such cases an increase in line capacitance by using double conductor construction is not an economic disadvantage.

The formula for capacitive susceptance of a double conductor line of usual capacity is

$$b = \frac{4\pi f\, 38.8 \times 10^{-9}}{\log_{10} \dfrac{s^2}{mp}} \text{ mhos per mile} \qquad (2)$$

CORONA

Values of corona voltage, that is, the voltage at which corona starts, are shown in Fig. 6 for 1 and 2

conductors per phase, where m, the separation of the 2 conductors of the same phase, is 6 in. Very little increase in corona voltage is obtained by using 2 small conductors of the same type as the single large one. This is in general true at separations other than 6 in. More increase in corona voltage is obtained by using 3 or more conductors per phase. The use of a hollow or cored conductor gives a considerable increase in corona voltage.

Measurements of the corona voltage with 2 and 3 transmission line conductors per phase are given in reference 8, p. 82, and also in the first edition of the same book, published in 1915, p. 71 and 72.

If a double conductor line and a single conductor line have the same calculated corona voltage, the operating voltage of the double conductor line should be kept lower than that of the other, because when corona does start, as in stormy weather, the double conductor line has twice as many conductors on which loss takes place.

The formula for corona voltage of a double conductor line of usual spacing, assuming an average irregularity factor m_0 of 0.85, is

$$e_o = 105 \, \rho \log_{10} \frac{s}{\rho} \tag{3}$$

A number of features relating to the use of 2 and 3 conductors per phase are discussed in reference 7. In this work a rather large spacing between the paralleled conductors, namely 18 in., was assumed.

Mechanical Features and Costs

A transmission line with 2 conductors per phase could be constructed using a type of hanger already developed and tried out for electric railway catenaries.

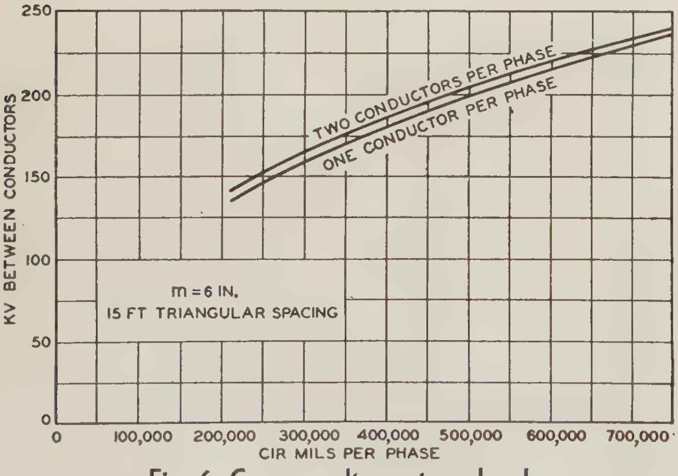

Fig. 6. Corona voltage at sea level

It would be more expensive than a single conductor line of equal mechanical strength. The duty on the towers, and their height, would be greater due to approximately twice as much wind and ice load. More clearance would be required and shorter spans might be needed. More margin of safety would be required in the tensile strength of the conductors, for although each might be pulled up to the proper tension, it would not be certain that one conductor would not take more than its share of the tensile load at some later time. The cost of stringing the conductors would be greater. Since the increase in ice load is perhaps the greatest disadvantage, the use of double conductors is of most interest for southern districts, where ice load is not encountered.

The additional cost due to the mechanical features of the double conductor construction is to be balanced against the value of the advantages to be obtained. If circumstances are such that the voltage drop in the line must not be more than a certain percentage, then 20 per cent reduction in reactance permits a corresponding increase in the allowable power load. In such a case the additional cost is to be compared with 20 or 25 per cent of the entire cost of the transmission line. This assumes that methods of controlling the voltage, as by synchronous condensers, are not considered applicable, and that the only way in which the power can be increased is by decreasing the reactance or providing additional circuits.

An increase in current carrying capacity or in corona voltage might be an additional advantage, but such an increase would probably not by itself justify the special construction, for ratings now in use. The current carrying capacity or corona voltage of a single conductor line could usually be increased 30 per cent without increasing the cost of the entire transmission line more than a few per cent, by using a heavier conductor or one of about 30 per cent larger diameter. The cost of the conductors is only a fraction of the cost of the entire line. Such a conductor, however, will not give 20 per cent less reactance. The large reduction in reactance is therefore the most important feature of the double conductor construction.

In conclusion, the advantages shown are as follows: Approximately 20 per cent less reactance; the opportunity in some cases to add to the conductivity and power rating without scrapping the old conductors; the almost entire elimination of skin effect; and the increase in current carrying capacity of nearly 30 per cent. The disadvantages are the greater clearance and mechanical strength required, particularly where ice load is important, the cost of hangers, and the increased cost of installation.

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The Significance of Noise Measurements

Dirt has been defined as being matter out of place; likewise noise may be regarded as misplaced sound. Sounds that are attractive musical notes under one circumstance may be distressingly annoying under other conditions. Present knowledge of noise and its effective control is summarized here.

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SOUND is a general name for anyhing that is heard including music, speech, and various kinds of noise. The word "noise" implies nnoyance, and includes: such separate disturbances s hammer blows, footsteps, or the slam of a door, nany sustained tones which would be considered nder some circumstances to be musical, the complex ounds emitted by almost all kinds of machinery, and nusic and speech when considered as a disturbance f the hearing sensation (that is, when the reception f that particular music or speech is not desired by he listener).

"Noise" also refers particularly to the complex listurbance caused by a group of people talking ndependently, as an audience does before a meeting s called to order, or any other complex jumble of listurbances perceived by the sense of hearing. In actory or office buildings there is a surprising amount f this complex disturbance which is the combined ffect of people talking and moving about, various ieces of machinery operating in different parts of he building, the operation of typewriters and ventiating fans, water running in pipes, and so on. In a usy street there is much noise of this sort, the effect f many different causes.

Simplest Sound a Pure Tone

The simplest sound is what is known as a "pure one." A pure tone has both intensity (amplitude) nd frequency (pitch), and consists of a regular notion of the particles of air which lie between the ource and the listener. By virtue of this motion he pressure of the air at any particular point beomes (many times per second) alternately greater nd less than the average. The frequency of this alternation is the frequency or pitch of the sound. To be strictly accurate, the manner in which the pressure changes at any point as a function of time must be what is known as sinusoidal variation if the tone is to be a pure tone.

If the variation of pressure with respect to time is not sinusoidal and yet is regular to the extent that the complete mode of variation is continuously and exactly repeated (many times per second) the sound is what is called a "musical tone." The effect is the same as if several pure tones (each having a frequency which is a multiple of the fundamental frequency) were produced and heard simultaneously. When such an equivalent set of pure tones is identified, the "musical tone" is spoken of as having been analyzed into its components—the "fundamental" and the "harmonics." The difference recognized when the same "note" is played on different musical instruments arises from the different wave shapes or modes of vibration of the air when set in motion with the same fundamental frequency by the different instruments. This usually is expressed by saying that different instruments have different timber or quality or that they give rise to tones in which the different harmonics (or overtones) differ in strength.

The noise emitted by some machinery may be practically a "musical tone" as that term has just been defined. Many machines, however, emit noises which are the equivalent of several simultaneous "musical tones." The fundamental frequencies of these several components may bear no simple relation to one another, and the result is what would be called discord in music; but this aspect of the matter perhaps is overshadowed in the mind of the listener by the effect of the persistence or repetition of the particular combination of sounds, a disagreeable effect never attempted in music.

Music and speech, when regarded as noise, differ from the noises usually made by machinery in that they change rather rapidly their characteristics of frequency and amplitude. That is, during the brief time that any particular note (in music) is being held, or for the duration of a particular sound such as a vowel sound (in speech), the sound may be analyzed into component "pure tones"; but very soon, as the music goes on to the next note or the speech goes on to the next speech element the set of component pure tones is changed. During the transition from one note to another or from one speech element to another the motion of the air particles may not at all correspond to periodic motion.

If many people are talking at once the number of frequency components in the resulting noise becomes so great that, so far as the analytical apparatus of the ear (or of most physical measuring apparatus) is concerned, components of *all* frequencies over a wide range are present. Of course the detailed conditions change rapidly, but if the number of voices involved is large there is established a sort of dynamic equilibrium which is registered by the ear as a fairly constant noise. Conditions similar to this may arise from other causes. The noise of "air rush" from a fan or near any rapidly moving piece of machinery, apparently because of the rapidly shifting arrange-

ssentially full text of a paper presented before the A.I.E.E. Lynn, Mass., ection, March 23, 1932. *Not published in pamphlet form.*

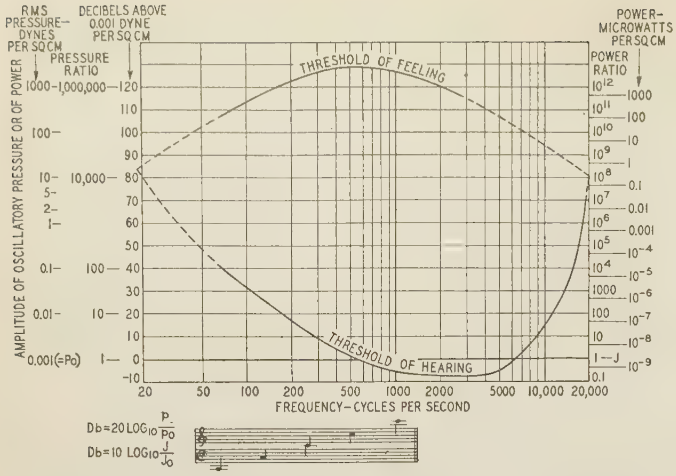

Fig. 1. Range of auditory sensation for the average human ear

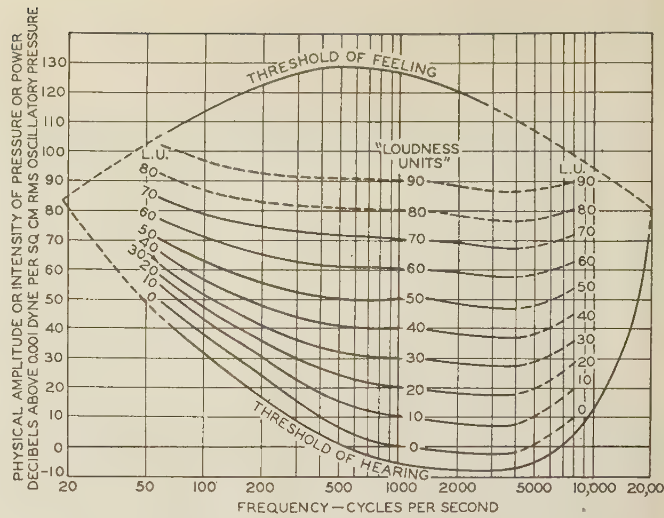

Fig. 2. Area of average human auditory sensation showing "equal loudness" contours

ment of air eddies, seems to have this characteristic of indefinite frequency. Such a noise of course may include or be accompanied by component tones of perfectly definite and sustained frequency.

Range of Human Perception

The "auditory sensation area" of the average human ear is shown in Fig. 1 where the abscissae represent frequencies plotted on a logarithmic scale. It may be noted that tones having frequencies anywhere in the range from 20 to about 20,000 cycles per second may be perceived by the ear. The limits differ widely for different individuals and there is a tendency for the upper limit to be reduced with increasing age of the observer.

Frequencies are plotted on a logarithmic scale for two reasons: (1) it accommodates conveniently the extensive range of frequencies involved, and (2) on such a scale the musical intervals such as octaves, fifths, and so on, which appear to have a rather fundamental importance in human comprehension of sounds are represented as equal intervals regardless of frequency. That is, the interval from 100 to 200 cycles per second is an "octave" as is also the interval from 2,000 to 4,000. The note represented in musical notation as "middle C" has a fundamental frequency just a little above 250 cycles per second.

The ordinates of Fig. 1 are values of the physical amplitudes of the tones at the ear of the listener. These may be indicated in several different units and may be expressed in terms of the pressure variation of the air or in terms of the power transmitted. The striking fact is the extreme range of amplitudes which may be perceived as sound, a range in the order of a ratio of 5,000,000/1 in terms of pressure variation or of $10^{13}/1$ in terms of power. For a diagram such as this to cover such an extensive range it is practically imperative to plot the values logarithmically, as has been done here. It is convenient in the practical work of measuring noises to refer to their amplitudes by a logarithmic scale such as the "decibel" scale. The "bel" or the "decibel" is fundamentally a unit of power ratio, and when used to state the amplitude of a noise the reference value of power (or the corresponding pressure variation) must be expressed or implied.

As a unit of noise measurement the decibel (db) has the practical advantage of being roughly the minimum change of amplitude which ordinarily can be detected, considering the whole range of audition. It is not by any means a perfect fit in this respect, but it is much better than any non-logarithmic unit would be.

Comparison of Loudness

Figure 2 shows what are called "equal loudness contours" for pure tones. If a listener be asked to observe the difference in 2 different pure tones sounded one after the other he probably will be more conscious of a difference in frequency (pitch) than of a difference in loudness. This is because of our training, and the habit of associating noises with their sources. Noise is observed from a given source under widely varying conditions of loudness depending upon the distance from the source and upon the amount of absorbing material such as room walls between the listener and the source. The frequency of a note from a given source is subject to much less variation. It is the frequency of the noise, then, that is the more important clue to the interpretation of noises heard. (Usually complex sounds rather than simple tones are heard and the habitual association of sound with source depends upon several frequency components being heard simultaneously.) However, it is possible to decide which of 2 tones sounds the louder, provided there is sufficient difference between them, even though the 2 tones be of different frequencies.

From another point of view, given the proper physical equipment for producing sounds of varying amplitude, it is possible to make a sound which seems as loud as a 1,000-cycle tone of standard loudness. The "equal loudness contours" in Fig. 2 connect points representing tones which, from the average results of many such experiments, seem to impress the average observer as being of equal loudness.

Hence the position of a plotted point relative to these oudness contours is an indication of what may be alled the "physiological loudness" of the corre- oonding tone. A numerical value may be given to ne physiological loudness of a tone of any frequency y stating the physical amplitude of an equally loud one of some standard frequency, say 1,000 cycles er second.

A musical tone, machinery noise, or other complex oise can be assigned a value for loudness in essen- ally this same manner by comparison with a pure one of standard frequency adjusted to equivalent oudness and measured for physical intensity. This eads to the definition of the "loudness units" of any oise as the "decibels above 0.001 dyne per sq cm rms oscillatory pressure)" of a 1,000-cycle pure tone which appears equally loud when the 2 sounds are ompared. It would be very difficult to determine ne loudness of an ordinary noise if a *direct* compari- on really were required. The "noise meter" in ffect makes this comparison, but what it actually neasures is the amplitude of all the noise components, ntegrating their effect after weighting them accord- ng to their frequencies and the experimental data n equivalent loudness, considering the components s pure tones.

From a practical standpoint it is more important o know how annoying a noise from a certain source vill be rather than to know how loud it is. This uestion goes beyond both the physical considera- ons of noise and the physiological question of oudness; it is a complex psychological question. pparently the annoyance of a noise depends upon ne loudness of its components and in a complex way pon their frequencies. Annoyance also depends pon circumstances, such as whether the noise seems ne normal accompaniment of the work in hand or is istracting. A carpenter probably gets some sort f satisfaction out of a good clear "bang" each time e hits at a nail with a hammer whereas a disinter- sted neighbor may be severely annoyed by the same ound.

Reduction of the amplitude of the loudest noise omponents in a complex noise may be presumed to educe the annoyance caused by that noise. The relative annoyance of two complex noises having different frequency components, such as the noises coming from motors of different design, involves questions of "masking" of one component by another, questions of discord between the several components, and questions concerning the relative annoyance of the different components considered as pure tones. Incidental observations made in the course of various noise investigations indicate that pure tones annoy different observers in a very different manner, considering annoyance as a function of frequency. However, that is a complex matter of psychological research which so far has not been investigated comprehensively.

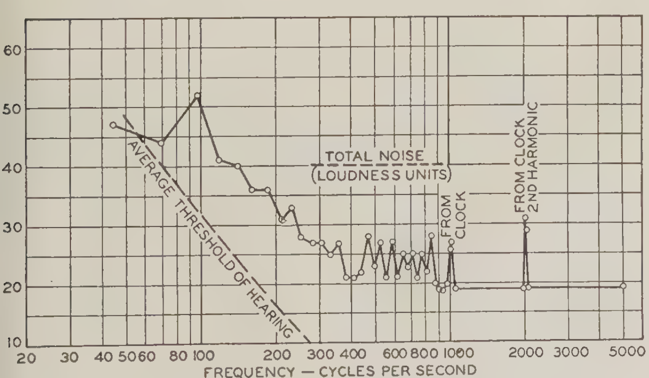

Fig. 3. Analysis of room noise in a laboratory office

The weighting to compensate for the differing response of the ear to different frequencies makes the "total noise" as measured in loudness units less in this case than the maximum noise as expressed in decibels. Readings were taken arbitrarily at each division of the analyzer frequency dial

Sources of Noise

In considering briefly its production and distribution, sound, in the physical sense, may be considered as one form of power, quantitatively microscopic, transmitted through the air and other media. Usually the immediate source of the energy transmitted to the air is the mechanical vibration of some surface, such as the sounding board of a musical instrument or the vibrating surfaces connected with a piece of machinery. The discovery of the "cause" of a noise usually implies some further explanation of the connection between the vibrating surface and some more fundamental source or energy. A satisfactory explanation of a noise requires a knowledge of the fundamental energy source, the mechanism of transformation into vibration, and the means by which the vibration is transmitted to a definite "sounding board."

Noise Measurements

Included in the term "noise measurements" are several different measurements including the determination of: the physiological value for "total noise," in "loudness units"; the frequencies of the principal components of the noise; and the physical amplitude or the equivalent loudness of the several noise components. Also, the closely related measurements of frequency and amplitude of mechanical vibrations involved in noise production may be included in the category of noise measurements.

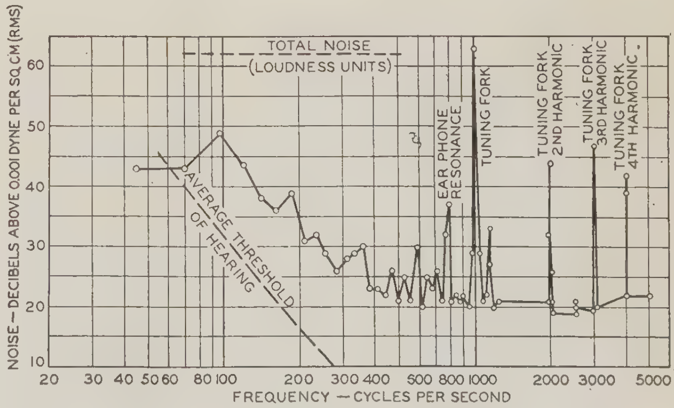

Fig. 4. Analysis of the room noise of Fig. 3, as augmented by sounds from a 1,000-cycle tuning fork

Results of noise measurements made in one particular room are shown in Fig. 3, plotted logarithmically the same as for the first 2 figures, except that the scale is somewhat larger and only a part of the auditory sensation area is shown. The noise in this case consisted largely of a jumble of various low frequency noises none of which were constant. The noise as a whole is equivalent in loudness to that of a 1,000-cycle tone of an intensity 40 db above 0.001 dyne per sq cm; that is, the noise is one of 40 loudness units. Because of the weighting of the total to compensate for the different sensitivity of the ear for different frequencies, the "total" is less in loudness units than some of the indefinite low frequency components as measured in decibels. The 2 small components of definite frequencies (1,000 and 2,000 cps) were readily identified as coming from a nearby clock connected to a piezoelectric standard for radio frequencies.

After observing the measurements of room conditions as shown in Fig. 3 further readings of the noise level were made at the same place after starting an electromagnetically driven tuning fork, the sound of which was brought to the vicinity of the microphone by means of a telephone receiver. This superimposed noise simulated a very simple machinery noise and produced the effects shown in Fig. 4 where it may be noted that the low frequency jumble remained practically unchanged. The definite noise component occurring at 800 cps arose from the fact that the telephone receiver was designed for resonance at 800 cps. At 1,000 cps may be noted the fundamental note of the tuning fork, and at 2,000, 3,000, and 4,000 cps, respectively, the second, third, and fourth harmonics of the tuning fork note. The "total noise," which consisted principally of the 1,000-cps tone, may be noted to agree rather closely with the physical amplitude of that component.

Obviously the values obtained in these measurements depend not only upon the source of the noise, but also upon the relative positions of the measuring device (the listener) and the noise source, particularly if the latter be a complex piece of machinery. Less evident, but nevertheless true, the amplitude or loudness of a noise depends upon other surrounding conditions such as the sound reflecting characteristics of walls and furnishings, and the manner in which the source of noise (such as a machine) is supported.

"Noisiness" undoubtedly is a characteristic of certain machinery, but its measure in comparable physical units requires carefully detailed specification of the many relevant conditions. In many cases "noisiness" probably is not a fault of any one of the several pieces of machinery involved in a specific case but rather the result of unfortunate chance relationships within the group.

Noise measurements are beginning to be used as a basis for standards of acceptable "quietness" for certain products. Noise measurements provide the principal means used in all efforts to reduce noise; they are effective because:

1. They establish standards by which the effect of changes may be compared, whether the changes be of design of equipment, operating conditions, or even legal restrictions. The ear, used directly, not only is inaccurate, but is terribly misleading unless a *direct* comparison of two noises is to be made.

2. Noise measurements aid in detecting "sounding boards" in complex apparatus. Design changes of these parts or the application of sound absorbent material reduce the noise.

3. Measurements of noise and vibration frequencies are effective because they usually indicate the fundamental source of the sound energy.

Once the mode of production of a noise is understood its reduction may be accomplished relatively easily by reducing the primary driving impulses, by interfering with the transmission of power between its source and the sounding board, by changing the physical characteristics of the sounding board, or by intelligent application of sound absorbing material.

Transmission Towers Span Railway Tracks

Transmission lines are carried into the city of Milwaukee, and through adjacent territory, on railway rights-of-way. Special towers have been developed to span the tracks in the more highly congested districts, and studies have been made to indicate which type of tower is the most economical.

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EXISTING rights-of-way of the interurban railway system are utilized where feasible for the location of transmission towers for the 132-kv and 66-kv lines of the Milwaukee Electric Railway and Light Company and its associated companies. As a result of this practise, 4 different types of tower line construction have been developed. They are as follows:

1. Standard square base towers
2. Two-track bridge type towers
3. Vertical side bridge type towers
4. Four-track bridge type towers

Based upon "The 60-Cycle Primary Transmission System of the Milwaukee Electric Railway & Light Company and Associated Companies in Wisconsin and Upper Michigan" (No. 32M3), presented at the A.I.E.E. Great Lakes District Meeting, Milwaukee, Wis., March 14–16, 1932.

The latter 3 types are used on railway right-of-way vhere the width available does not allow the use of he standard square base towers. The conductors ı these cases are carried in part or entirely over perating tracks. In addition to the high-voltage ransmission line conductors, these towers carry he railway catenary construction, supply feeders, nd signal circuits. Provision is made also for the ıstallation of from 2 to 4 medium voltage transıission lines.

The primary transmission system, operating at 32 kv or 66 kv, is used to transmit bulk energy rom the generating stations to step-down subtations, and to interconnect the Milwaukee system vith hydroelectric plants in the northern peninsula f Michigan. The capacity of 132-kv transmission nes from 2 of the generating stations, near Milvaukee, to the various substations in the Milwaukee rea, has been standardized at 90,000 kva; 300,000-ir mil copper conductors are used together with 0,000-kva transformers. The lines south of Milvaukee are 4/0 copper conductors. The remaining nes are 3/0 and 4/0 ACSR.

TANDARD TOWERS

The square base double circuit tower is used for ll lines on right-of-way not occupied jointly with

Figs. 1, 2, and 3. Standard square base towers. Fig. 1 (left) is a suspension tower, Fig. 2 (middle) an angle tower, and Fig. 3 (right) a transposition tower

ilway, or on railway rights-of-way of sufficient idth to allow space for their installation. These owers as well as the various types of bridge towers e designed to support 300,000-cir mil copper conıctors strung so that the tension under heavy loading nditions will be 40 per cent of the ultimate. Under the same conditions, the tension in the 3/8-in. Copperweld ground wires will be 39 per cent of the ultimate.

The conductor spacing on the suspension tower is 13 ft vertical, with 26 ft and 32 ft horizontal separation, the middle arm being the longest in order to provide a horizontal offset of 3 ft between the conductors of a circuit. The vertical separation on transposition and angle towers has been increased to 16 ft in order to avoid reduction of clearances to ground below those obtained on the suspension tower. On angle towers, the arms are offset an amount equal to the horizontal displacement of the conductor due to the transverse load, thus placing the conductors in an approximately symmetrical position with respect to the head of the tower.

The number of different types of towers used in any line is a question of economics. Four different designs (exclusive of transposition towers) are used at various angles up to a right angle turn. Conductors are supported in suspension up to angles not exceeding 45 deg. Towers at angles of 0 deg to 45 deg are divided into three designs; namely, a standard suspension tower for angles not exceeding 4 deg (Fig. 1); an angle tower for larger angles but not exceeding 20 deg (Fig. 2); and a third type for greater angles up to 45 deg. The range of angles covered by each type will depend upon the number and size of angles in the line in question; but it is believed that the foregoing classification will prove to be economical for average conditions. A fourth design is a dead-end tower, suitable for use at angles greater than 45 deg and not exceeding 90 deg.

Transpositions are made on one tower without a reduction in length of, or crossing of, wires in the adjacent spans. Transposition towers (Fig. 3) are built by installing transposition arms on the body of a 20-deg angle tower, which when used for this purpose will withstand the loads specified for transposition towers.

Since the suspension towers are designed to withstand the unbalanced longitudinal loads due to 2 broken conductors, it has not been necessary to place strain or semi-strain towers at intervals in the line.

TOWERS ON RAILWAY RIGHT-OF-WAY

The utilization of private rights-of-way for both railway and transmission has called for marked departure from the square base double-circuit type of tower. Three general types of towers have been designed to best fit the conditions under which they are used.

The 2-track tower (Fig. 4) is a standard double-circuit tower set on a bridge structure spanning the tracks. It has been used on a right-of-way entering the city from the north through a suburban and city district.

The vertical side tower (Fig. 5) is similar to a standard double-circuit tower except that the face toward the track is vertical. The conductors are thereby placed partially over the tracks, requiring less width of right-of-way outside the tracks than if a standard tower were used. At present only one

tower has been erected. The other tower and connecting truss will be erected when additional circuits are needed. These towers have been used along the rapid transit line entering the city from the west, where the right-of-way was of sufficient width to accommodate them.

The 4-track tower (Fig. 6) has been used on the same line but closer to the city where real estate values preclude the purchase of more right-of-way than is essential for railway purposes. This design centers the conductors over the rails and as close to each other as is practicable. Each set of conductors in an approximately vertical plane comprises one circuit so that they can be worked on while the others are operating. Access to the middle circuit is obtained by walking on a grating placed on the bottom of each truss. The truss is 5 ft in height. A modification of the 4-track tower is shown in Fig. 7. It was used where the railway grade was high and not of sufficient width to accommodate 4 tracks, at a point where the tracks cross the Menominee River.

All towers over tracks have been designed to accommodate railway trolley and feeders, and 26.4-kv lines in addition to the 132-kv lines.

Of the different types of towers utilized in extending the 132-kv system on or along private railway rights-of-way, it is obvious that the structures bridging the tracks cost more than the vertical side towers. The type of towers to be installed is a question of economics based upon real estate values at the particular location. In many of the outlying suburban areas there was the alternative of using the 2-track bridge type tower and utilizing, for the most part, the same right-of-way; or of purchasing additional right-of-way to permit the use of standard towers. The results of a study of this situation showed that the bridge tower is more economical if the cost of additional right-of-way for transmission only exceeds $1,200 per acre. If the cost is less than this amount, it is economical to purchase additional land adjacent to the existing railway right-of-way in order to accommodate standard towers.

Tower Design

The design of the standard towers is for the most part along conventional lines, differing only in some details. One such departure from the usual practise is the use of the "drip plate," a 16-in. octagonal steel plate placed above the point of insulator support. Operating experience shows that under certain favorable conditions, water which collects on the crossarm brace will flow down the brace to the end of the crossarm and drip over the insulators, forming icicles. These icicles shunt the porcelain and have sufficient conductivity to permit a flow of current which will operate the ground relays. The function of the drip plate is to act as an umbrella in diverting the drip water away from the insulators.

The system is within the area defined by both the state and the national codes as a heavy loading district. Records show that wind has not exceeded 40 miles per hr (4 lb per sq ft pressure) while there was ice on wires, and the ice formation has not been as heavy as $^1/_2$ in. ice radial thickness. However, it is known that in other parts of the state, ice has formed more than one inch in thickness. In order to guard against service interruption, a load equal to that imposed by one inch ice and 8-lb wind pressure at 0 deg fahr has been specified. This is approximately double the loading specified by the codes. All towers are designed to withstand transverse and vertical loads resulting from these conditions plus the unbalanced load due to any 2 conductors being broken. The unit stresses in the material are such that the elastic limit will not be exceeded if the loads specified are increased 10 per cent on standard towers and 25 per cent on towers spanning tracks.

The steel grillage type of anchor requiring no concrete, has been generally used for suspension and the lighter angle towers, while concrete has been used for the heavier towers and all towers over tracks. The Malone anchor has been utilized to some extent for suspension towers and found satisfactory where the soil conditions are suitable for its use.

The normal span length of the lines over 4 tracks is 510 ft. This is limited by the length of the maximum railway catenary span, which, on account of the track alinement, was found to be 255 ft. Other supports intermediate between the transmission towers carry the railway equipment only, resulting in a transmission span double that of the catenary span. The towers over 2 tracks are spaced at 600 ft. This also is double the railway catenary span, which on account of larger radii curves, is 300 ft. The double circuit square base towers are spaced at 650 ft maximum. This has been found to be an economical span length for the average conditions under which the various lines are constructed, taking into consideration width of right-of-way, land values, and clearances from other structures.

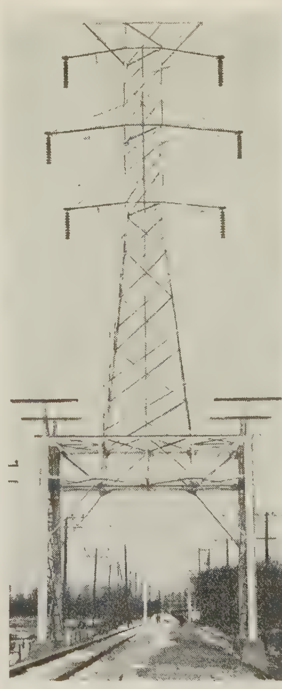

Fig. 4. (Left) A typical 2-track bridge tower

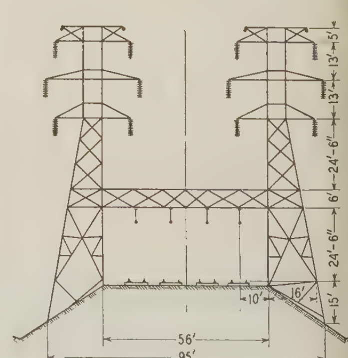

Fig. 5. (Below) Elevation of a typical vertical side bridge tower with truss

ɜround Wires

Lines constructed previous to 1925 were not quipped with ground wires, but provision was made or one wire at the tip of the tower approximately ³/₂ ft above the top conductors. Operating experience available at that time on this and other ıtility systems, indicated that the presence of a round wire did substantially reduce the number of nterruptions due to lightning. Ground wires were

Fig. 6. (Left) A 4-track, 3-circuit bridge tower

Fig. 7. (Right) A 2-track, 3-circuit bridge tower

hen installed on all existing lines and since that time ave been included in the initial construction of all ines.

Ground wires are $^3/_8$-in. Copperweld supported y a suspension clamp on suspension towers and by lead-end clamps at angles and dead-ends. The uspension clamp provides a flexible support, miniızing, if not eliminating, the bending of the wire t its support. This method of support is used as n added precaution against mechanical failure of he ground wire.

The line placed in operation early in 1931 is quipped with 2 ground wires, each of which is offset ft horizontally and separated 12 ft vertically rom the top conductor. The sag of the ground vire is less than that of the conductor, making an verage vertical separation of approximately 16 ft.

nsulation and Protective Devices

The older 132-kv lines are equipped with 10 $^3/_4$-in. spaced suspension insulator units with 15-in. orns at the conductor end. The horns are effective ı protecting the conductor against burning, and the ɔwer insulators against damage by power arcs. This insulator string has an impact flashover of pproximately 700 kv. Flashovers and the power arc following have often damaged the porcelain of the upper insulators of the string, but there has been only one case, and that during a severe rain storm, when service could not be restored without replacing insulators.

Flux controls, devices having the general appearance of horns, but having insulators on the tips, are used on 32 miles of line. Laboratory tests show that these devices will protect the insulators against discharges of from 50,000 to 70,000 cycles per sec. Although it has been shown that such frequencies can be present on the line, it has not been shown that they occur frequently enough to warrant protecting against them. This is borne out by the operating record of this line, which, from the time of the installation of the flux controls in 1926 to date, is substantially the same as the other circuit carried on the same towers, but equipped with 15-in. horns.

The most recent line to be placed in operation is equipped with V.S. arcing horns on a suspension insulator string consisting of 10 $5^3/_4$-in. units. The impact flashover of this assembly is 820 kv The purpose of the horns is to protect the porcelain against damage by confining the arc to the horn tips, thus permitting restoration of service immediately following the oil circuit breaker operation. Dead-end insulation consists of 2 12-unit strings in parallel and equipped with V.S. horns on which the impact flashover is 980 kv.

At the Lakeside generating station, near Milwaukee, each outgoing 132-kv line is fed through its own transformer bank, which is protected by a lightning arrester against surges originating on the line. At substations the transformers are protected by a lightning arrester connected to the bus. Ultimate plans provide for an arrester on each bus section to which transformers are connected.

At all generating stations and substations connected to lines equipped with V.S. horns, the horn-gaps nearest the station are set to protect the station apparatus as well as the line. At switching stations where there is no equipment with bushings connected to the 132-kv line, no reduction need be made in the length of gap used on the suspension tower. Laboratory tests show that this gap of approximately 47 in. will always flash over before the bus insulators or the 4-unit pillar insulator on the air-break switches. At stations where there are bushings to be protected, the gap has been reduced to $36^1/_2$ in., resulting in a flashover value just below that of the bushings. These protective horn-gaps are placed on the dead-end line insulators, except where they would be in close proximity to an air-break switch. In this case they are placed on the tower one span away.

The 66-kv system of the Wisconsin-Michigan Power Company in upper Michigan consists of both steel tower and wood pole construction. The steel towers are of the conventional double circuit type similar to those on the 132-kv system, except that neither the loads nor clearances are as great. Where a single circuit line of small conductors meets the requirements, the wood poles are the more economical. Another advantage over steel towers is that they can be set along highways and streets, where they are available for distribution circuits.

Brass Tacks in Economics

Less investment money and more buying money is needed today; one proposal to increase buying power without harming business is by the drastic taxation of great incomes. This is the thirteenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
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SCIENCE never is finished, but the engineer cannot wait. While research is exploring the theory of stresses, the engineer must take what facts he can get, use the means available, and drive the job forward. It is the same with economic fact-finding. Look at the bituminous coal industry: Facts are basic, but not dynamic. Making the economic machine run is a problem in simplification, decision, and determined action. What is wanted? Where is the sticking point? What power is available? What will it cost?

There are two incompatible economic projects. One is that of bringing the great accumulations of capital through the storm with the least possible loss. The other is involved in this question: If we can easily make all the things any reasonable person wants, and plenty for everybody, why not do it? Radicals and conservatives will favor the first project, the former because they know it leads to revolution, the latter because they do not know that the attempt is hopeless. The second project is a constructive, common-sense idea, and therefore peculiarly suited to the engineering mind. Following is an outline of this second project.

Too Much Investment Money Poisons Business

The sticking point is in the construction and machinery industries, the production of "capital goods." Too much money goes into factories and office buildings and new coal mines; then overhead consumes all the profits, and paralysis sets in. The system as a whole is as inefficient as possible. First we build factories that cannot run and floor space that nobody will occupy; then we spend several years doing nothing of any consequence. Our work is stultified by the irrational behavior of finance.

Investment money flows into industry and trade when prospects look good, and causes overexpansion; then it flows out and causes deflation. It causes instability and profits thereby, and for that reason it is poisonous to business. The Federal Reserve is supposed to counteract this action of private finance; but it has not been strong enough. Investment money flows into overequipment, and when industry has been well poisoned it vanishes in bankruptcies, wrecking business, but not removing the excess equipment. There is too much investment money. The opportunity to invest money without poisoning business is limited. Moreover there is too little buying money. The income of the country must be directed more to useful consumption and less to economic poison.

What power is capable of turning the flow of money into useful channels and releasing us from the vicious circle of wasted work and unemployment? History indicates that those who suffer most are likely to be most interested in applying a remedy. Working drawings must be intelligible to workmen; any plan that is to come down out of Utopia and take on reality must sacrifice comprehensiveness to simplicity. The most obvious device is communism, but it hardly seems suited to the American temperament. A more practical method of steering money into consumption would be one that would be acceptable to the workers and the middle class, because together they have the necessary power to put it into action. Heavy taxes on the great individual incomes with rebates for approved contributions, would effectively reduce overbuilding and turn the money into public and semi-public construction; this would increase buying power without harming business.

Drastic Taxation of Great Incomes Will Stabilize Business

What will it cost to stabilize business growth by drastic taxation of great incomes? First, it will cost giving up forever the hope of becoming a multimillionaire. Success, beyond a certain point, will have to be measured in honors, fame, offices, anything else but vast sums of money. The money is needed to lubricate business via the buying market. Second, it will mean slowing the maximum rate of construction of new plant. Our present *average* rate is slow because we stop periodically. This could be avoided if we would tax consumption and use the money to tear down old plant; but although it would cure overequipment it would be inefficient because too much energy would go into premature replacement. There is a finite optimum rate of replacement, which with our tremendous productive power we could overpass easily. By diverting capital funds into the destruction of old plant as well as to building cultural equipment, we could get the maximum of useful products out of the system in the long run.

The third cost of the limitation of capital accumulation will be that it will tend to decentralize initiative. The incentive for centralized control will be reduced and that for setting up small concerns

This article has been checked by Virgil Jordan, economist, McGraw-Hill Publishing Company, Inc., New York, N. Y.

ill be increased. That may seem horrifying at rst; and yet, could any arrangement be more nefficient than the present one? In any event it the price of freedom, and of the overall efficiency hich we lack now.

No system with the high productive power of our wn can be made to run unless the construction of quipment is artificially kept in check. If we go for centralization, we shall be forced to adopt ocialism as a means of limiting investment. If e limit the volume of investment money by taxaon, we can avoid the abolition of individual initiave. The latter method crudely but effectively ill do the job; it is simple enough to be compreended by the voters who have the power to put into action; and the cost is less than the cost of rifting on into collapse and revolution. It will e well for engineers to consider these points, deise a still simpler and more effective plan if posble, and then push for action.

litor's Note: Pursuant to the invitation of the Engineering Foundation, the itors will be happy to receive comments, criticisms, or discussions pertaining to is or other articles published in this series.

Welding Steel Structures

WELDING with gases and electricity re relatively new processes but have a background f more than a decade of scientific research. In ecent years such welding has been adapted to buildngs and bridges. Noise elimination, economies, and ase of application are a few reasons for adoption y the structural steel industry.

Welding came to the attention of engineers durng the World War as an aid in shipbuilding. Prior this time, it had been used with varied success in epair work, particularly on the railroads. Good elds could be produced under certain conditions, hereas poor welds resulted under others. Weldng experts were unable to give satisfactory reasons or this, but investigations started during the war ere continued. With the organization of the merican Welding Society and its research departnent, the American Bureau of Welding, this rearch work was expanded.

Leading structural engineers a few years ago egan to study the application of welding to the abrication of steel structures. Investigators in is country and in Australia undertook tests. A w important structures were fabricated by weldng, including some gas holders in Australia, some small ships here and in Europe, and a few small buildings in this country and in England.

An outstanding contribution to the extension of welding in structural work was the 5-yr program of the Structural Steel Welding Committee. Its scope and thoroughness commanded the attention of architects and engineers. It involved the fabrication and testing of several thousand specimens welded by 61 welders at 39 shops and tested at 24 laboratories including college and commercial institutions, and the U.S. Bureau of Standards. This research disclosed no harmful effect on the base metal due to welding.

Since tests on 2,495 specimens indicated that joints commercially welded by qualified welders may be expected to possess strengths within 12 per cent of general average results, engineers and architects may feel secure in expecting in their completed structures, the strengths required.

A few random instances will bring out these advantages. A new hotel building had to be erected at Hot Springs, Va., between 2 existing structures. It was necessary to avoid the noise of riveting. This structure was 12 stories high, and was the first so-called tier building of this size to be welded. A 5-story heavy duty warehouse was constructed by American Bridge Company for Westinghouse Electric & Manufacturing Company. The continuity of beams and girders which was provided resulted in a 12 per cent saving in steel.

A 10-story office building in Cleveland, housing physicians and dentists, was enlarged without disturbing the occupants. The gas torch and the electric arc made this possible, thus saving the owners thousands of dollars in rentals. It was necessary to make only small openings in the old walls uncovering the face of the old steel where the connections were to be made. Much wrecking was eliminated.

Steel building frames may be welded with either the gas torch or the arc. The largest structure thus far welded with a gas torch is a research laboratory 75 ft wide, 260 ft long and $42^1/_2$ ft high, at Niagara Falls. The tallest arc welded structure is a 19-story office building for the Dallas (Tex.) Light and Power Company. The heaviest welded truss to date weighs 60 tons; it has a span of 96 ft and a height of 18 ft. In the United States several hundred steel structures have been welded either totally or partially. No failure has occurred in any welded joint.

Aside from the economic value of noise elimination, in many locations, the saving lies principally in the use of less steel in trusses or plate girders. In the multi-story building frames consisting of welded beams and columns, the decrease in weight of steel is small unless the beams be made continuous; but thus far the cost of additional welding has offset the saving in steel. In several buildings, some of them 14 stories in height, the cost to the owners when the shop work was riveted and field work welded, was the same as if both shop and field connections had been riveted. This equality reveals a decided advance in a short time. In ordinary roof trusses savings in weight of steel are pos-

om *Research Narratives*, April 15, 1932, published by the Engineering Foundaon, 29 West 39th St., New York, N. Y. Based upon information contributed W. Spraragen, secy., American Bureau of Welding, New York, N. Y.

sible amounting to as much as 36 per cent. Similar savings are obtained in plate girder construction.

The American Institute of Steel Construction is sponsoring the battledeck floor for buildings. It consists of thin flat steel plates two feet or more wide resting upon the upper flanges of parallel I-beams. As the adjacent edges of two plates run along each I-beam and a narrow space is left between them, these edges are welded together and at the same time to the top of the I-beam, thus producing a composite beam. Automatic machines are available for the welding.

More than 125 municipalities have adopted welding in their building codes. With accurate design data, control of products is made sure through the employment of qualified welders and inspectors, and designs adapted to welding.

Welding has been helpful in steel buildings to resist earthquake and wind, which in some instances would require unusually elaborate designs if riveted. An example is the new headquarters of the Southern California Edison Company, Ltd., in Los Angeles.

All-welded steel frame houses are possibilities of the future. Several such experimental houses have been erected at a cost which compares favorably with wooden structures. General adoption would provide an outlet for more than a million tons of steel annually.

Electrochemistry and Hoover Dam

Two mining authorities here outline some of the possibilities for electrochemical developments at or near Hoover Dam in connection with the expected availability of large quantities of cheap power and water and the known mineral deposits of the West.*—Editors.

WITHIN 6 years the construction of Hoover Dam and the power plants probably will have reached the operating stage and this vast new source of power then will be available for industry.

The average annual flow of the Colorado River is calculated at approximately 24,000 cfs, and if this average flow can be maintained the year round at the full head provided by the 580-ft dam about 1,000,000 hp will be generated. Government engineers, taking into consideration the probable range in flow and head, have set the figure for power contracts at 660,000 firm horsepower, which can be assured at all times of the year. During the months of heavy run off the power plants should be able to generate their full 1,000,000 hp; hence there will be 340,000 excess or secondary horsepower. The cost of firm power at the switchboard will be close to 2.15 mills per kwhr, equal to $14.05 per hp-yr, and the cost of the secondary or off peak power will be close to 0.8 mill per kwhr, or $5.22 per hp-yr. At no place in the country can such cheap power be obtained today.

The electrochemical industry is in a state of flux because the cost of power from its old sources has increased so much (to $30 per hp-yr at Niagara) that the industries have gone to Canada and Norway and built new plants. Dr. C. G. Fink, secretary of the American Electrochemical Society and an accepted authority on matters concerning the electrochemical industry, made the following statement at the hearing on disposal of Boulder Dam power before Secretary Wilbur in Washington, D. C., in November 1929: "It is my opinion and conviction that the American electrochemical industry will be ready to absorb all of the power developed by the Boulder Canyon project as soon as it is available." Doctor Fink also stated that "transmission costs are higher than transportation costs for raw material or finished product."

The power situation as briefly outlined, coupled with the fact that the Hoover Dam area is one of the richest in the world in raw materials used by the electrochemical industry, insures the creation of an immense electrochemical and electrometallurgical industrial center in southern Nevada. The following is a brief résumé of the more important industries that will be created to use this cheap power, and a brief description of the metallic and non-metallic resources in southern Nevada and contiguous territory.

Electric Furnace Industries

Numerous electric furnace industries are possible. Calcium carbide can be manufactured, for limestone of high purity exists in unlimited quantity near the dam. Although coke will have to be brought in from Utah, the low power rate at the dam will more than offset this.

Cheap power may make possible the calcination of this pure limestone in electric furnaces, obtaining quicklime as one product, carbon dioxide gas as another. Dolomite also occurs in unlimited beds near at hand, to be calcined for various uses, as done there now with oil furnaces. The carbon dioxide gas would fit into the picture to convert synthetic ammonia to carbonate, which in turn may be elutriated with ground gypsum to form ammonium sulfate fertilizer, and produce hydrated lime as a by-product. By this process millions of tons of ammonium sulfate are manufactured annually in Germany.

Ferro-alloys of vanadium, molybdenum, manganese and silicon can be manufactured from ore supplies all within 40 miles of the dam. Tungsten will come from central Nevada. Pig iron can be brought from Utah, or iron for such alloys can be produced from

* Abstracted from an article "Possibility of Electrochemical Industries at Hoover Dam" written by Jay A. Carpenter—professor of mining, University of Nevada—and Alfred Merritt Smith—mining engineer, Nevada State Bureau of Mines—and published by the American Institute of Mining and Metallurgical Engineers, Inc., in "Mining and Metallurgy" for August 1932.

e large deposits in southern California and Nevada. San Bernardino County, California, is a splendid eposit of at least 5,000,000 tons of magnetite, only 0 miles by rail from the dam site. In northeastern iverside County, California, is the great Iron Chief eposit, conservatively estimated at from 20 to 75 illion tons, distant only 200 miles from the dam. ther large deposits also exist in the West.

The sponge-iron process has possibilities wherein tah would be called on to supply cheap slack coal r the necessary reduction before the electric smelt-g of the sponge iron. The pioneer plant at Heroult, alif., several years ago proved electric iron smelting be practicable, and success dependent on costs one. Here is a wide new field in the direct produc-on of steel and steel alloys from the ore.

itrates and Ammonia

Very cheap power and an absence of coal suggests e adoption of some method of nitrogen fixation ing only air, water, and power, such as the Birke-nd and Eyde and Doctor Schonherr's methods in e in Norway by plants consuming 360,000 hp. he nitric acid so produced has high market value, d nitrate nitrogen is desirable for explosives manu-cture, a large industry on the Pacific Coast. High-wer explosives for military protection can be manu-ctured near the dam, a point remote from air attack d near the great new United States munitions orage depot at Hawthorne, Nev.

Although the Haber-Bosch ammonia process now used to produce most of the world's synthetic am-onia, nearly all of the plants consume coke and coal th for power and to produce the gases used. owever, in the last few years synthetic ammonia ade from hydrogen derived from the electrolysis of ater and nitrogen obtained from the air, has become importance where cheap power is available.

Tadanac, near Trail, B. C., offers an outstanding ample of water electrolysis on a commercial scale. ydrogen from the electrolytic disassociation of ater, and nitrogen from a liquid air unit are used in oducing synthetic ammonia by direct combination der pressure with a catalyst. This, too, although e plant is not remote from good sources of Washing-n coke and coal. Tadanac long has been a great nter for electrolytic lead refining, and it was there at selective flotation of complex lead-zinc ores made great advance. The $10,000,000 fertilizer plant w under construction there consists of an elec-olytic hydrogen unit to produce 3,000,000 cu ft of drogen per day; a liquid-air unit for the produc-on of nitrogen; and a synthetic ammonia unit to oduce 47 tons of anhydrous ammonia per day. ius have low-priced power and basic materials built this great group of industries in a location more mote from markets and having a climate much ferior to that of the Hoover Dam for living, labor, d operating conditions.

ectrolysis

Electrolysis of salt produces sodium hydrate and lorine, the base and acid for a wide range of chemical uses. Four large salt deposits in Virgin Valley, 50 miles from Hoover Dam, contain at least 25,000,000 tons of rock salt. Rock salt and also calcium chloride occur in inexhaustible quantities at Bristol Dry Lake, San Bernardino County, 150 miles from Hoover Dam. Great quantities of sodium hydrate might find use in the refining of California petroleum. Hydrochloric acid made from the chlo-rine may possibly be used in the manufacture of pure iron by electrolysis of a solution of ore in acid. Cheap power would be the key to this method, with the natural resources ready at hand.

The Metals

Zinc. The U.S. Bureau of Mines reports that Arizona, Nevada, New Mexico, Oregon, Washington, and Utah mines produced 93,018 tons of recoverable zinc in 1930. For the same year Colorado and Montana produced 155,718 tons. Most of the ore was reduced in electrolytic plants in Montana and Idaho and represents 26.5 per cent of the total United States production. During the years 1930 to 1932 the mines of Pioche, Nevada, enormously increased their ore reserves; they now have about 4,000,000 tons of ore blocked out, with the possibility of much more lead-zinc-manganese ore to be developed soon. To provide for this increased production, particularly in Nevada, large concentrating and calcining plants may be built at Pioche, about 150 miles north of the dam. The calcine could be shipped to the dam for electrolytic refining. About 16 per cent of all the sulfuric acid used in the United States is produced by zinc-roasting plants. Probably all of the Pioche acid would be absorbed by industries at the dam, chief of which should be the refining of blister copper.

Copper. In the West, there are electrolytic copper refineries at Great Falls, Mont.; Tacoma, Wash.; and a new plant at El Paso, Tex. Doctor Fink states that these will not take care of western copper output, but will leave all of Nevada (54,601 tons in 1930) and half of Utah and Arizona (about 500,000 tons in all) to be sent east for refining. It would appear that for more economical operation a plant should be located at Hoover Dam, in the center of the heaviest producing districts, and a point on the direct route to the Coast.

Aluminum. Doctor Fink points out that all aluminum used in the western half of the United States is subject to an expensive cross-haul, bauxite from Arkansas going east for reduction and then west again as metal. Six million pounds per year is shipped to the Orient, in addition to large amounts used in the western states. A deposit of pure alunite is being developed at Sulphur, Humboldt County, Nev. Marysvale, Utah, also is a source of this aluminum-potash mineral. Other localities in Nevada and Utah may be able to supply some of this ore. A commercial process for recovering both aluminum and potash from alunite should not be difficult to work out, given cheap power and abundant water.

Manganese. Various deposits of manganese ore occur in the western states. In Nevada, at Gol-

conda and Ely, small tonnages of high-grade ore are produced, and at both Las Vegas and Pioche are large bedded deposits. The probable tonnage of manganese ore, associated with zinc and lead in the Pioche district, now amounts to about 4,000,000 tons. Possibly 2 or 3 times as much will eventually be developed. The Combined Metals Company at Pioche is perfecting a commercial process for the separation of manganese, which can probably be carried out most advantageously at the dam site, where, in any event, the next steps of making ferromanganese or using the ore in chemical industries would be carried out. Only 10 miles northwest of the Hoover Dam is another large bedded deposit of manganese ore, which geologists Hewett and Webber of the U.S. Geological Survey estimate to contain at least 500,000 and possibly 1,000,000 tons. As manganese ore imports in 1930 were 585,568 long tons, and domestic production of all classes, including 708,000 tons of manganiferous iron ore was only 845,000 tons, the need of cheap domestic manganese is seen. Ferromanganese can be made cheaply in electric furnaces at the dam site, and thus be ready for market at exceedingly low cost for the ores.

Tungsten. Nevada and California together produce most of the tungsten consumed in the United States. The largest western production is made at Mill City, Nev., and Atolia, Calif., which together produce about 80 per cent of all that used in the United States. (In 1930, 702 tons of 70 per cent WO_3 was produced.) A portion of Nevada's production of 64 per cent of the total, which is now shipped to Niagara Falls for reduction, could be converted to ferro-tungsten at the dam, for western and Oriental consumption, at a great saving.

Other Minerals and Metals. Within commercially practical distances of Hoover Dam lie tremendous deposits of other minerals and metals including alum, borax, brucite, gypsum, clays (bentonite, kaolin, diatomite), feldspar, fluorspar, limestone, magnesite, molybdenum, silica (good quality), sodium sulfate, sulfur, and vanadium.

Economies Possible

To the materials already mentioned must be added platinum, gold, silver, mercury, cobalt, and bismuth, all of which are found in Nevada and California near the Hoover Dam site. Great economies to the mining industry seem possible through the establishment of reduction plants and refineries at this source of electric energy.

Distribution System Lightning Protection; Operating Experiences With Lightning Arresters

Operating experience demonstrates that lightning arresters provide sufficient protection to justify their installation on electric power distribution systems even where low arrester ground resistance cannot be obtained. Limited experience with the interconnected lightning arrester ground and grounded secondary neutral confirms the results of laboratory and field tests covered in a group of articles published on p. 633–47 of the September issue of ELECTRICAL ENGINEERING.

PROTECTION of electric power distribution systems from disturbances due to lightning is a problem of major importance, since many interruptions to customers are due directly to troubles from that source. Statistical studies show that lightning arresters provide sufficient protection on distribution systems to justify their installation economically. Results of 3 such studies on 3 typical large power systems are covered in the 3 articles immediately following this introduction.

The first article, by Roper, treats of a cooperative investigation on the system of the Commonwealth Edison Company, Chicago, conducted by several lightning arrester manufacturers in cooperation with the power company. The second, by Haines and Corney, gives the results of a study on the system of the Edison Electric Illuminating Company, Boston, in a region where high ground resistances prevail. The third article, by Dambly, Ekvall, and Phelps, covers a study on the different types of lines that make up the distribution system of the Philadelphia Electric Company, and includes field tests with the interconnected primary arrester ground and grounded secondary neutral.

From the results of these and similar studies, quite definite rules now can be laid down for reducing the effects of lightning disturbances on distribution circuits. As determined in previous investigations, a marked improvement in protection is effected by increasing the arrester density, that is, the number installed per square mile of area protected. The age

d size of transformers also appear to have some ect, the smaller transformers being more susptible to lightning troubles as are those of older sign. Low resistance for arrester grounds appears be of great importance, although considerable otection can be obtained even with ground retances as high as 1,000 ohms. There is a differce of opinion as to whether grounded systems are s susceptible to lightning disturbances than are grounded systems. A difference of opinion also ists in regard to the shielding effect of tall buildgs, trees, and other structures.

—Experience on a Typical Urban System

By
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FELLOW A.I.E.E.

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BY TAKING ADVANTAGE of owledge gained from a 20-yr statistical research vestigation of lightning protection for distribution cuits (Fig. 1), it appears possible to reduce the mber of transformer troubles caused by lightning Chicago to less than one case of trouble per year r thousand transformers in service. This article esents some of the later results of that 20-yr study.

Following the development of the cathode ray cillograph in form suitable for tests on lightning resters, it was noted that test results, as then made d interpreted, placed the several types of arresters a different order of merit from the order indicated field investigations. This resulted in a conference th the lightning arrester manufacturers on the bject in January 1927, at which time plans were rmulated for determining the causes of these disepancies. Practically all of the additional inrmation on the subject recorded in this article has sulted from the intensive study begun during this nference. During the succeeding years 6 more nferences were held; as a result, practically all of e differences which appeared in the first conference ve been reconciled. As the manufacturers of htning arresters now are able to make tests with e lightning generator and to interpret the results means of the cathode ray oscillograph, so that by ch studies the relative merits of various types of esters can be closely determined, the detailed tistical investigations in Chicago no longer are rranted and hence have been practically disntinued.

d upon "Studies in Lightning Protection on 4,000-Volt Circuits—III" (No. 9) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 9, 1932.

CHICAGO DISTRIBUTION SYSTEM

The system of distribution in Chicago is a 4-wire 3-phase 2,300/4,000-volt system with the neutral grounded at the substations. All of the 606 circuits leave the substations underground; the feeders and about $^1/_5$ of the mains are underground. On August 1, 1931, there were 33,093 transformers connected to the overhead mains; in addition 1,593 were installed in manholes or vaults and connected directly to underground primary mains. Over 800,000 customers are served by this distribution system, which covers about 120 of the 210 square miles within the Chicago city limits.

All line transformers are single-phase, with 2,080-volt primaries and 115/230-volt secondaries. Lighting transformers are connected between a phase wire and neutral; the secondary neutral wire is well grounded along the secondary mains and on the customers' premises. Transformer cases are not grounded. Large power installations consist of 3 transformers connected in Y on the primary and in Δ on the secondary; the common point of the primary connections is not connected to the primary neutral, and the middle point of one transformer secondary is grounded. Smaller power installations consist of

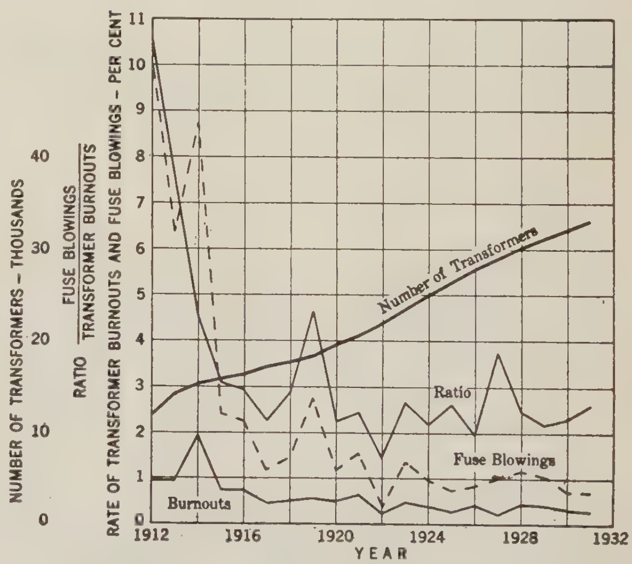


Fig. 1. Records of transformers and lightning troubles for a 20-yr period

Even though the number of transformers doubled between 1915 and 1931, the actual number of transformer burnouts and fuse blowings remained fairly constant at 105 and 275 per year, respectively

2 transformers each connected between one phase wire and primary neutral with the secondaries connected in open Δ. Secondary lighting mains generally are only one block long, but about $^4/_5$ of these secondary mains have their neutrals connected with the neutrals of mains in adjacent blocks.

One 3-kv and one 300-volt arrester (Fig. 2) are installed on the same pole with each lighting transformer; similar installations are made at the banks of 2 or 3 power transformers with the further limitation that the maximum number of phase arresters on

Table I—Results of Examination of Transformers Burned Out in Chicago by Lightning During 1927–30, Inclusive

Apparent Lightning Entrance	No Transformers Examined	Per Cent
Primary only:		
Phase wire	133	28.0
Neutral wire	32	6.8
Phase and neutral wire	42	8.9
Total, Primary only	207	43.7
Secondary only	100	21.1
Secondary and primary	105	22.2
Doubtful	38	8.0
Indeterminate	24	5.0
Total	474	100.0

Note: In these investigations a transformer is considered to be burned out when it cannot be restored to service without removing it from the pole. About 40 per cent of the transformers were repaired without replacing the coils.

transformers in any one block is 3. Similar installations are made on all cable poles. No lightning arresters or similar devices are installed in any of the substations, on the secondary mains for light or power, or on transformers connected to underground mains.

At present 15 types of 3-kv arresters are in use on the system, which, for the purpose of this investigation, was divided into 162 areas with only one type of arrester in any area. The several areas for each type are scattered throughout the city. For grounding the arresters 10-ft ground rods are used except in sandy regions, where 15-ft rods are used; in the few rock areas special methods are employed.

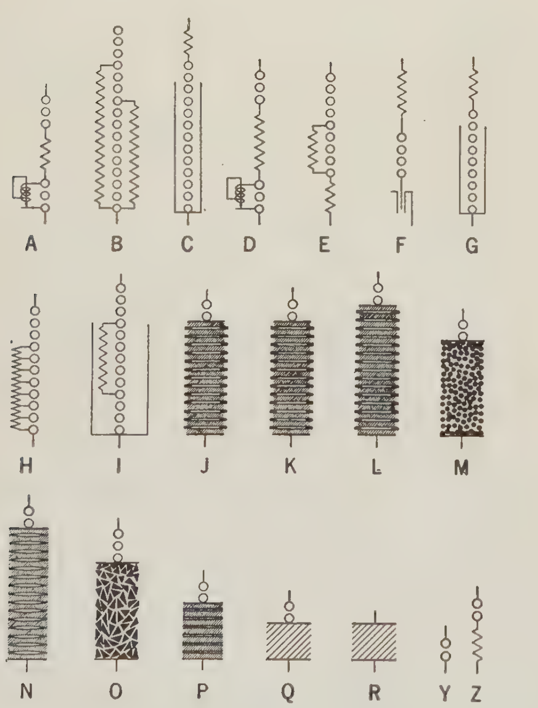


Fig. 2. Electrical diagrams of arresters used

Gaps and resistors are shown by conventional symbols; lower end of diagram is ground side. Types A to R are 3-kv arresters. Types Y and Z are 300-volt arresters. In types C and G narrow grounded bands of metal are carried up the sides, while in type I, a grounded metallic cylinder surrounds the lower $^3/_4$ of the arrester. Arresters J to R are valve types. Arresters are arranged in the order in which they were installed on the system

Examination of Burned Out Transformers

Records of the examination of 474 transformers burned out by lightning (Table I) indicate that burnouts starting in the secondary winding (Fig. 3) were nearly half as numerous as those starting on the primary. Lightning potentials on the secondary service wires, however, have caused but little trouble on customers' premises. Information obtained in the examination of the transformers confirms the suggestion in the 1914 paper of the author that careful attention should be given to clearances of leads inside and outside the transformer case. (See "Experiences With Line Transformers," A.I.E.E. Trans., v. 33, 1914, p. 685.)

Evidences of direct strokes, as indicated by shattering of poles or cross-arms, were found on only about 15 poles per yr., or one in 9,000. Only about 5 per cent of the transformer failures appear to be caused by direct strokes. Apparently there are practically no traveling waves on the distribution system. This assumption is based upon the fact that records for transformers at the open ends of

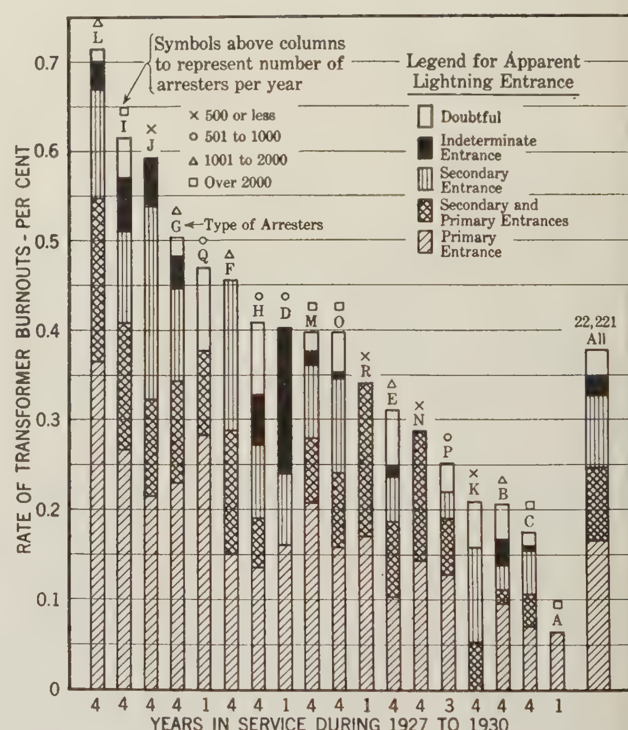


Fig. 3. Performance of different types of arresters

Averages are not corrected for size, age, or density of transformers. Probable errors in the individual cases are from 10 to 25 per cent, except for type A, for which only one year's performance is shown

primary wires show that the percentage of trouble is about 20 per cent below the rate for other transformers. Were traveling waves existent on the system, there would be an increased percentage of trouble due to piling up of potential at these points.

Effects of Various Factors

From the results of the investigation certain

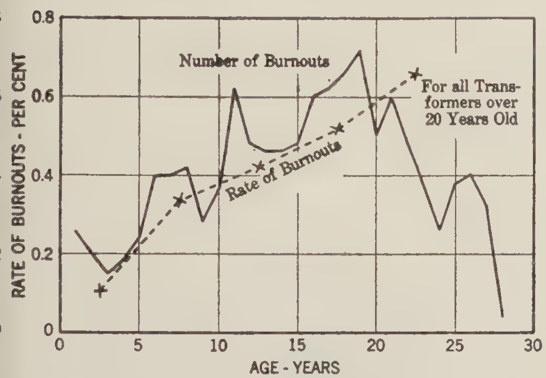
ctors have been found to affect lightning troubles the distribution system as follows:

1. Underground primary mains.

e 1,593 transformers installed in manholes or vaults and connected underground primary mains had a rate of burnout due to lightning only $^1/_{30}$ of 1 per cent per annum in the past 5 years.

2. Grounding of primary neutral.

e advantage of a 4-wire 3-phase system with neutral grounded the substation is that it permits the installation of 300-volt arters on the neutral wire of the overhead primary mains and 3-kv esters on the phase wires, whereas with the neutral ungrounded esters rated at 3 kv and 6 kv, respectively, are required. During ightning discharge the 300-volt arresters break down quickly er which the primary neutral wire acts as a ground wire to reduce maximum voltage which otherwise would be reached by the mary phase wires. This, together with the use of phase arresters lower voltage rating gives the grounded neutral system an adtage over systems with ungrounded neutral by a reduction of



g. 4. Relation between age of transformers and burn-outs due to lightning

Figures shown are averages for 1927–31

ut 40 per cent in the maximum crest voltage to which the transners are exposed to induced discharges. This advantage also ndicated by the fact that, although no arresters are installed in stations, flashovers due to lightning in the substations in Chicago entirely unknown and burnouts of voltage regulators due to tning in recent years have averaged about $^1/_{20}$ of 1 per cent per um. In addition, the number of cable failures due to lightning been only about 2 per year though there are 3,800 points of nection to the overhead mains.

3. Density of arresters.

s subject, a most important one, was covered quite thoroughly he author's 1920 paper "Studies in Lightning protection on 4,000-t Circuits—II" (A.I.E.E. Trans., v. 39, part 2, p. 1895). The clusion reached in that paper was that "There is a very marked rovement in the effect of lightning arrester protection with an ease in density. . . . "

4. Size of transformers.

ent records confirm statements in preceding papers that lightning bles decrease with increasing transformer size. In Chicago some action of troubles has been effected by discontinuing purchases of nsformers of capacities lower than 5 kva.

5. Age of transformers.

rate of burnouts has been found to increase several fold with age transformer (see Fig. 4).

6. Resistance of arrester grounds.

ords indicate that apparently any extra expense to reduce the stance of lightning arrester grounds below 50 ohms is not warted.

7. Shielding effect of trees and buildings.

near as could be determined, the shielding effect of trees, build-, and other tall objects against induced discharges is practically for Chicago conditions. There is no way of determining even roximately the extent to which trees and structures shield the against direct strokes.

8. Extent and intensity of lightning.

ough each type of arrester was installed in several areas widely

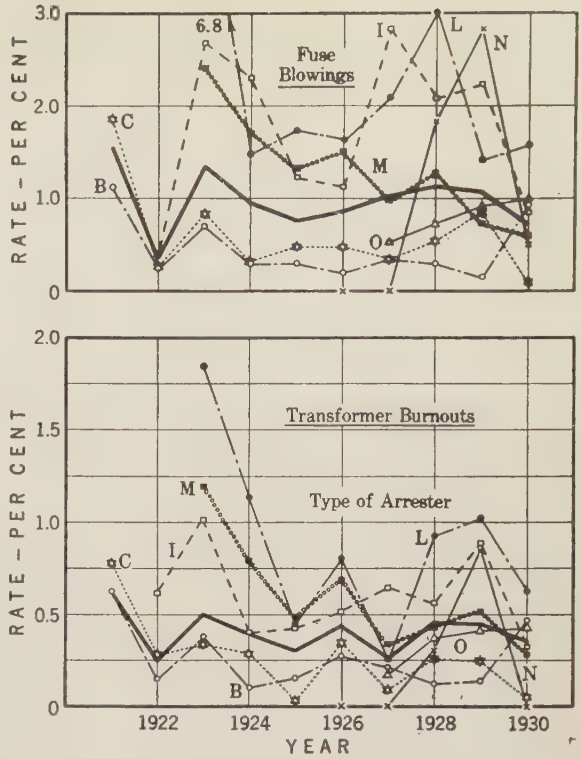


Fig. 5. (Right) Records of trouble on transformers protected by typical arresters

Heavy solid line represents average for all arresters on the system

scattered over the city, the intensity of lightning in these areas varied from year to year; consequently annual variations in protective characteristics of the arresters were observed, as indicated in Fig. 5. This also indicates that to obtain reliable data from such investigations, a great many arresters must be used and the field trial must extend over several years.

Comparison of Different Types of Arresters

Records indicate that one of the types of arresters (B, Fig. 3) first placed on the market about 20 years ago and withdrawn 10 years later, has not been excelled in its protective efficiency, but its maintenance rate was rather high. It consists of a series of metal gaps with 2 shunting resistors enclosed in a wooden box. At the beginning of 1922 the manufacturers offered valve type arresters in place of the former gap type; these new valve arresters have required about $^1/_3$ of the rate of replacements that obtain for gap arresters. The ideal valve arrester would be one without a series gap that would discriminate between induced discharges of high frequency and the 60-cycle follow current, opening wide the valve for the former and closing it promptly against the latter, repeating this action year after year without reduction in its protective efficiency.

In recent years several papers have been presented before the A.I.E.E. on the subject of coordination of insulation on transmission lines. These investigations indicate the desirability of similar coordination between lightning arrester performance and the maximum induced discharges to which the distribution transformer windings and bushings are subjected.

Suggestions for Minimum Lightning Troubles

1. Use the 4-wire 3-phase system of distribution with grounded neutral.

2. Where transformers or cables are connected to overhead primary mains, install low voltage arresters on the neutral wire and valve type arresters suitable for the Y voltage on the phase wires; avoid duplication within 500 ft, and reduce the number, for Chicago conditions, by $^1/_3$.

3. Use transformers having insulation on the coils and leads that will not deteriorate with age and that will withstand a transient voltage test safely above the voltages to which the transformers will be subjected in service when protected by arresters.

4. If conditions warrant a second ground rod for reducing the resistance of the lightning arrester ground, install also a second ground wire down the pole and connect it to the second ground rod.

5. Select newest transformers for installation in districts of low arrester density and install the older transformers in areas of high arrester density.

6. Require each customer to ground the neutral wire of his house wiring to a water pipe on his premises.

7. Connect the neutral wire of each section of secondary mains to at least 2 ground rods; on long mains install ground rod connections at intervals not exceeding 600 ft.

8. Interconnect, to a reasonable extent, the neutral wires of adjacent secondary mains.

9. Interconnect the lightning arrester ground wire and the secondary neutral wire when the latter is well grounded.

10. Where transformers are connected to primary mains 1,500 ft or more distant from the nearest transformers, install on the pole about 600 ft from the transformers the same lightning arrester equipment as on the transformer pole.

11. Ground the lead sheaths of all underground primary cables.

By following these suggestions and giving the problem continuous engineering supervision, it appears possible to reduce the number of transformer troubles caused by lightning in Chicago, that is fuses blown plus transformers burned out, from 13 cases to less than 1 case of trouble per year per thousand transformers installed.

II—Experience on a System With High Ground Resistance

By

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FOR YEARS, lightning storms in the territory served by the Edison Electric Illuminating Company of Boston have been accompanied by numerous blown fuses, damaged and burned out transformers, and other troubles, all of which caused many outages to customers with consequent annoyance to them as well as expense to the company. This company distributes electrical energy in 40 cities and towns, embracing 650 square miles in and about the city of Boston. (See Fig. 6.) A total of 325,000 retail customers is supplied from 10,200 distribution transformers. All power customers are fed from 3-phase transformers of which there are 1,500 overhead and 500 underground. Of the single-phase lighting transformers, 7,300 are overhead and 900 underground. In general, the primary distribution system is of the 3-phase 4-wire radial type and operates at 2,300/4,000 volts with the neutral ungrounded. There are approximately 235 such circuits of which about $^1/_5$ of the circuit miles are estimated to be underground.

Prior to 1925, lightning arresters of conventional type had not been used to any extent principally because of the opinion that in order for this equipment to function satisfactorily it was absolutely essential to have low resistance ground connections. Those familiar with New England soil conditions realize that a low resistance ground at the foot of a pole is a rarity. This condition was emphasized in 1917 when the United States Bureau of Standards made a general survey of ground resistance conditions and found that they were worse in New England than anywhere else in the country. (See Bureau of

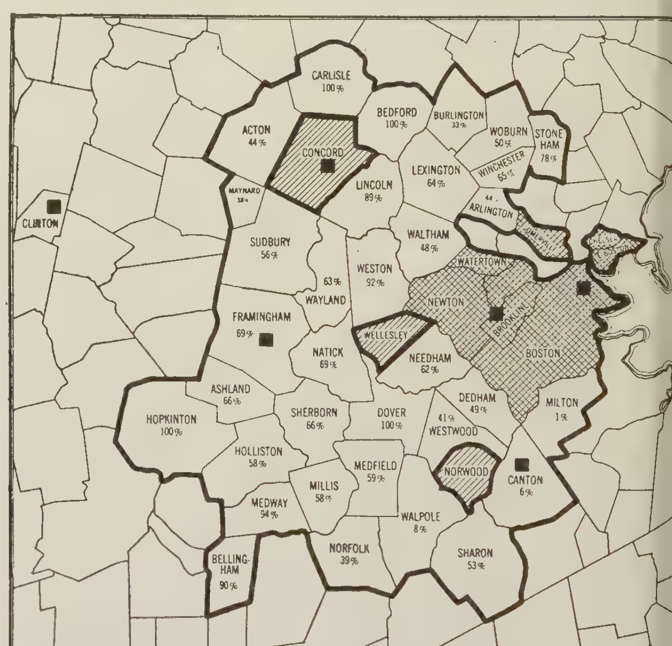

Fig. 6. Territory served by the distribution system of the Edison Electric Illuminating Company of Boston

Single crosshatched areas have municipal distribution. Double crosshatching indicates unprotected area. Black squares indicate observation stations of the U. S. Weather Bureau. Percentages given indicate degree of protection in their respective areas

Standards *Publication No. 108,* "Ground Connections for Electrical Systems," by O. S. Peters, June 1918.)

With the growth of the system, conditions were becoming so acute that early in 1923 it was decided to make a trial installation of several standard lightning arresters notwithstanding the fact that there was little hope of getting what was considered a low resistance ground. The first circuits to be protected were in areas where records had shown

Based upon "Lightning Protection for Distribution Transformers" (No. 32-44) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

Table II—Summary of Troubles on Distribution Transformers Due to Lightning in Protected Area

			Transformers With Lightning Arresters			Transformers Without Lightning Arresters			All Transformers			
No. of Weather Bureau Lightning Observations	Per Cent Protection	Avg. Ground Resistance	No. of Transformers	Troubles per 100 Transformers	Troubles per 100 Transformers per 100 Weather Bureau Observations	No. of Transformers	Troubles per 100 Transformers	Troubles per 100 Transformers per 100 Weather Bureau Observations	No. of Transformers	Troubles in Year	Troubles per 100 Transformers	Troubles per 100 Transformers per 100 Weather Bureau Observations
144	34	201	1,484	25.5	17.7	2,836	44.4	30.8	4,320	1,637	37.9	26.3
82	38	210	1,805	9.9	12.1	2,970	13.9	17.0	4,775	600	12.6	15.4
126	49	196	2,407	12.1	9.6	2,487	38.0	30.2	4,894	1,239	25.3	20.1
118	56	214	2,930	15.7	13.3	2,329	22.6	19.2	5,259	987	18.8	15.9
114	71	234	3,781	4.2	3.7	1,562	7.6	6.7	5,343	278	5.2	4.6

nsformer troubles due to lightning to be most ere.

From past experience certain areas in and closely acent to the city of Boston had shown a trouble e about $^1/_3$ of that of the rest of the territory, less. There is now a total of 3,400 overhead nsformers in these areas, none of which is proted by lightning arresters. As this section is more ckly settled than the rest, its comparatively low e is thought to be due to the shielding effect of uctures. As a result, no protection was intended these areas and consequently they have been ninated from the study. The protected area in ich there are now approximately 5,400 overhead nsformers, is shown in Fig. 6.

ETHOD OF CONNECTING ARRESTERS

Lightning arresters of 3 different manufacturers re selected, each having seemingly desirable aracteristics; all had porcelain housings, and were ed for circuits of from 4 to 5 kv. Single-phase nsformers, which are connected between a phase e and neutral, were equipped with 2 arresters, from each wire to ground; 3-phase transformers, ich are connected to each of the 3-phase wires, re equipped similarly with 3 arresters. It was nned to equip about 500 transformer installations year.

As lightning arrester protection was estimated to t an average of $50 per transformer, it was not med economically justifiable, in general, to install equipment on transformers under 7.5-kva acity. As the records showed, however, that nsformers on dead ends were more susceptible to ntning troubles than the others, it was decided to tect those as small as 5-kva capacity at these points. The first group of arresters was installed in 1925. cause of the previously mentioned opinion as to necessity for low resistance grounds, it was ided for the first trial group that lightning esters would not be installed unless a ground nection of 250 ohms or less could be obtained. on after the work was started, however, it was nd that even 250-ohm grounds were difficult to ain. Consequently in order to be able to comte a reasonable number of installations for obvation, the limit for ground resistance above which esters should not be used was raised to 1,000 ohms.

RESULTS OF STUDY

No attempt was made to analyze operating records until 1927 as the number of installations in service previous to that time was thought to be too small to obtain reliable data. From the procedure established, it may be noted that in any area selected for protection some transformers were protected and some were not. It was thought that in general this practise would give a means of comparing the performance of transformers protected with that of those not protected. Each year previous to the lightning storm season, all arrester grounds were measured for ground resistance; those over 250 ohms were treated with salt and water and/or had additional rods driven in an attempt to lower their resistances.

A summary of data collected for protected and unprotected transformers, arranged by years from 1927 on, is given in Table II. Results for 1927 show that the installation of lightning arresters on certain transformers decreased all types of lightning troubles on those transformers by 40 per cent, and all troubles except those classified as miscellaneous, by 50 per cent.

During 1928 lightning storms were much less frequent than in the previous year resulting in only about half as many transformer troubles as in 1927. The summary of troubles for this year as shown in Table II indicates that the troubles with protected transformers were much less than the troubles with unprotected transformers.

In 1929, as a result of the previous 2 years' experience, lightning arresters were installed at a more rapid rate and ground resistances up to 2,000 ohms for transformers larger than 10 kva were accepted, although as before, salt treatment was given where possible in an endeavor to lower the resistance of such installations. The summary of results for that year (Table II) shows even more strikingly the effectiveness of protection as in this year there was proportionately more than 3 times as much trouble on unprotected transformers as on protected ones. An analysis of troubles by transformer sizes showed that while transformers 5 kva and smaller constituted slightly less than 30 per cent of all the transformers in service, they accounted for more than 50 per cent of the troubles.

By 1930, 3 consecutive years of study had demon-

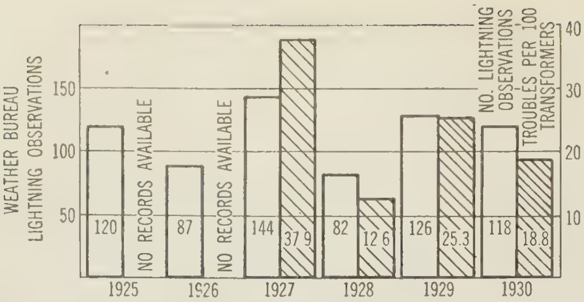

Fig. 7. U. S. Weather Bureau lightning observations compared to transformer troubles

strated the effectiveness of the protection afforded by lightning arresters. The fact that proportionately more troubles occurred on transformers of 5 kva and smaller capacity, and that in general the smaller transformers are more remote from maintenance headquarters, together with the improvements shown with increased arrester density, led to the decision that all transformers in towns in the protected area ultimately should be protected.

As a further result of the studies and in an effort to apply the new program most effectively all unprotected transformers where trouble had occurred more than twice in 1929, were equipped with arresters. Also a small group of towns where excessive lightning troubles had occurred were selected and arresters were added to give 100 per cent protection before the 1930 lightning season.

In 1929, as stated previously, it was learned that transformers of small sizes were particularly susceptible to lightning outages. The 1930 analysis brought out the same condition, but more strikingly: Of the total troubles 67 per cent was on transformers of 5 kva and smaller; this group constitutes 28.5 per cent of the total number of transformers.

Data Corrected for Storm Severity

As 100 per cent protection is approached, the means of comparing the effectiveness of the work tends to disappear and a need for some other measure to show the progress being made becomes evident. The United States Weather Bureau records observations of lightning storms from several stations in and about Boston. Lightning observations reported by the bureau have been totaled and called the "storm severity factor"; this factor is used as a divisor to modify the trouble rates in an attempt to render them more comparable. Locations of these observation stations are shown in Fig. 6 while Fig. 7 gives the total number of observations each year compared with the number of transformer troubles in the same year.

Reduction in trouble rate resulting from the application of arresters modified by the storm severity factor, is shown in Fig. 8 plotted against arrester protection in per cent. Extrapolation of the trend curve gives an indication of the improvement that may be expected by further additions of lightning arresters. As may be noted, this trend for the area considered is shown as a straight line. Other curves in Fig. 8 show the reduction in trouble rate for an individual town and for a group of towns; these are given to indicate the effect of complete protection in lowering the trouble rate. These particular towns were selected on account of the severity and frequency of storms in their respective localities.

Using this expectation curve as a basis, it can be shown for this system that the annual saving in cost of maintenance to be expected by the decrease of troubles anticipated from the protection of all the remaining transformers in the protected area, will be sufficient to finance the additional investment required for complete protection. Additional gains will be realized in decreased customer outage and

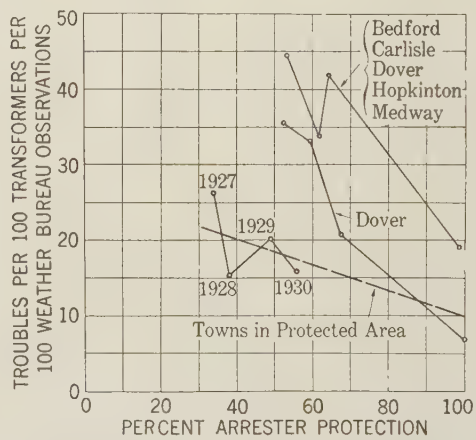

Fig. 8. Reduction of trouble rate effected by lightning arresters

decreased handling and overhead expenses, items not included in the cost analysis.

Arrester Density and Ground Resistance

Studies of the effect of lightning arrester density per unit area and of the effectiveness of various values of ground resistance were begun in 1927 and continued throughout the investigation. Results of these studies are plotted in Figs. 9 and 10, respectively. A distinct improvement as the density increased is indicated by Fig. 9; this seems to check conclusions reached in previous studies. (See "Studies in Lightning Protection on 4,000-Volt Circuits," D. W. Roper, A.I.E.E. Trans., v. 35, 1916, p. 655; and v. 39, 1920, p. 1895.)

As previously mentioned, the average ground resistance in the area served by this company is high, being over 200 ohms. In Fig. 10 it may be seen that for resistances lower than 100 ohms, decreased resistance makes a definite improvement in the effectiveness of arresters, whereas above that value the effectiveness is not reduced materially by higher ground resistance. The upper horizontal line on Fig. 10 shows the average trouble intensity for unprotected transformers. A comparison of the curves indicates that arresters even with extremely high ground resistances give valuable protection. In the course of early discussion of these data the question was raised as to whether the ground resistance

fered to 60-cycle current used for testing might be fferent from that offered to lightning waves. An vestigation made subsequently by one of the ghtning arrester manufacturers showed that resisnce values offered to lightning waves are appreciably ss than those offered to 60-cycle currents. (See Impulse Characteristics of Driven Grounds," H. M. owne, *G.E. Rev.*, Nov. 1928.) This may account a certain extent for the relative effectiveness of ound connections having high 60-cycle resistances.

As stated previously, lightning arresters from 3 anufacturers were used. Records of troubles were gregated and tabulated by manufacturers throught the investigation. A comparison of these data ow that for conditions as found on this system ere is little to choose between the different arsters.

During 1930 careful inspections were made of early all the transformers where fuses had been own during lightning storms. Evidence of arcing as found in nearly every case. The arcing seemed be concentrated on those transformers which were somewhat ancient design with small primary ishings, insufficient internal clearances, primary rminal boards, etc. Tabulation of the results

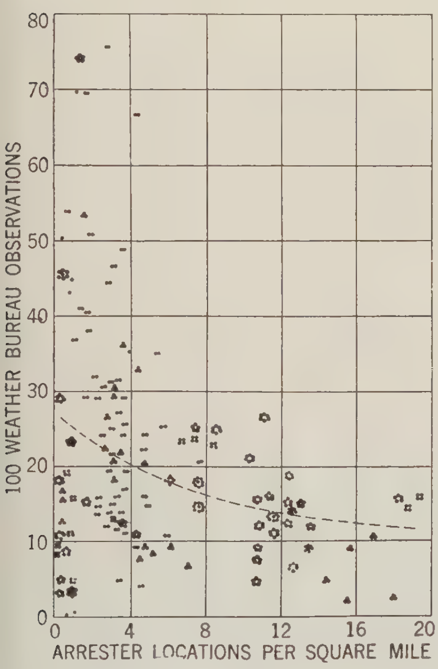

Fig. 9. (Left) Variation of transformer trouble rate with lightning arrester density, 1927–30

dicated that transformers made previous to 1910 ve several times as much trouble as those manuctured since then. Inasmuch as previous to this te high-loss iron for the transformer cores was used ite generally, the policy has been adopted of minating these old transformers from the system. l other transformers passing through the shop are built to increase internal clearances and are uipped with modern bushings.

ielding Effect of Structures

During 1930 additional data were obtained which dicated that the shielding effect of structures and other conductors may have a more pronounced effect in protecting transformers and fuses against lightning outage than previously had been recognized. Thus the trouble rate in any area appears to be influenced by a combination of the effects of shielding and arrester density, each of which contributes its share to the final result.

Results of 1931 Study

While the data for the year 1931 have not been studied carefully on account of lack of time, the summary in Table II shows a marked decrease in the total number of troubles as well as in the trouble rate. Again the rate of trouble on protected transformers is less than half that of the unprotected. The marked decrease in troubles is due in part to the rebuilding of about 25 per cent of the transformers and the removal from the system of most of the small transformers built prior to 1910. It should be noted that the improvement in operation of the protected transformers in general remains the same as in previous years even with nearly all the small troublemaking transformers removed from the system.

Conclusions

On the basis of results obtained to date, the following conclusions seem justifiable for this system:

1. Application of lightning arresters to line transformers in areas affected by lightning reduces the trouble rate by about 50 per cent.
2. Variation in ground resistance within the values readily obtainable in this territory has slight effect on the efficiency of arresters.
3. The value of treating grounds or the installation of multiple grounds in an effort to lower resistance is questionable unless by so doing the resistance can be lowered to about 100 ohms or less.
4. Insufficient electrical clearances in the smaller and older transformers are an important source of lightning trouble. Larger bushings and greater clearances are clearly indicated to be necessary features of correct transformer design.

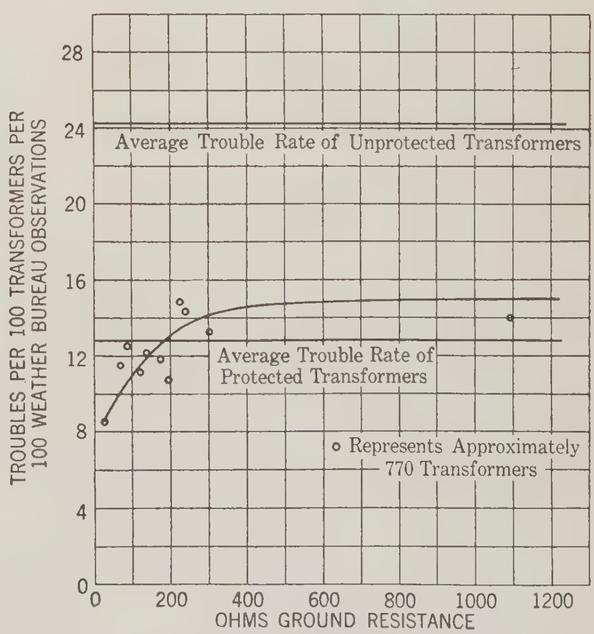

Fig. 10. Variation of transformer trouble rate with arrester ground resistance, 1927–30

III—Experience on a Diversified System

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INVESTIGATIONS of lightning troubles have been conducted on the distribution system of the Philadelphia Electric Company since 1921. Their purpose has been to determine: (1) magnitude and nature of trouble in various localities; (2) effectiveness of lightning arresters under field conditions; and (3) ways and means for improving service continuity. Up to and including 1929, studies were confined to the Philadelphia division. In 1930 they were extended to the entire system which includes 6 operating divisions having in service approximately 23,000 aerial transformers.

During the period 1921–29, investigations were confined to the analysis of fuse blowings and transformer failures. Comparisons of trouble on protected and unprotected transformers (reduced to a common basis of troubles per 100 transformers in service) appeared to indicate that lightning arresters were not providing satisfactory protection. This was attributed to the relatively high resistance of the arrester grounds, which average well over 100 ohms.

In 1930, the studies not only were extended to all operating divisions of the system but also were broadened to include many factors which from past experience appeared to be of major importance. Also in 1930 these studies were extended to the territory of the former Philadelphia Suburban-Counties Gas & Electric Company, and of the Susquehanna Utilities Company. This permitted investigations on a variety of types of distribution systems as follows:

1. 2.3-kv, 2-phase, 3-wire, ungrounded.
2. 2.3-kv, 3-phase, 3-wire, ungrounded, Δ-connected.
3. 4.1-kv, 3-phase, 4-wire, grounded, Y-connected.
4. 6.6-kv, 3-phase, 3-wire, ungrounded, Δ-connected.

From observations thus far it has been impossible to detect any difference in susceptibility to lightning between grounded and ungrounded systems.

Summary of Lightning Trouble, 1930–31

During 1930, approximately 5 per cent of the transformers on the combined system experienced lightning trouble. Of these, 68 per cent represent transformer fuse and fuse box trouble, and the remainder transformer (bushing, lead, or winding) trouble. Similar conditions were found to exist in 1931 also. Lightning trouble data for these 2 years are summarized in Tables III and IV.

In the light of these experiences, several different factors which appear to be of major importance to the lightning protection problems as a whole next will be discussed. This discussion is based largely upon experience in the Philadelphia division, for which

Table III—Summary of Transformer Lightning Trouble—1930

Division	Transformers: No. in Service	Transformers: Average Size, Kva	Total Troubles	Troubles per 100 Transformers: Fuse and Fuse Box	Troubles per 100 Transformers: Transformer	Troubles per 100 Transformers: Total
Philadelphia	8,467	32.8	230	1.5	1.2	2.7
Eastern	4,204	9.5	250	4.2	1.8	6.0
Schuylkill	3,830	9.7	69	0.6	1.2	1.8
Main Line	3,043	10.7	220	5.1	2.1	7.2
Delaware	2,299	22.3	20	0.0	0.9	0.9
Susq. Utilities	958	6.0	275	26.2	2.5	28.7
Total System	22,801	19.5	1,064	3.2	1.4	4.6

Table IV—Summary of Transformer Lightning Trouble—1931

Division	Transformers: No. in Service	Transformers: Average Size, Kva	Total Trouble	Troubles per 100 Transformers: Fuse and Fuse Box	Troubles per 100 Transformers: Transformer	Troubles per 100 Transformers: Total
Philadelphia	8,321	32.8	183	1.3	0.9	2.2
Eastern	4,581	10.1	317	3.1	3.8	6.9
Schuylkill	3,863	10.2	190	2.8	2.2	5.0
Main Line	3,197	11.4	221	4.2	2.7	6.9
Delaware	2,475	20.3	49	0.2	1.8	2.0
Susq. Utilities	1,182	6.0	96	7.2	0.9	8.1
Total System	23,619	19.2	1,056	2.5	2.0	4.5

more complete information was obtained than for the other divisions.

Size and Age of Transformers

Trouble was found to decrease with increasing size of transformers (see Fig. 11). The greater trouble on small transformers is believed to be due largely to (1) small clearances between leads and case, and (2) smaller bushings, thus permitting more flashovers at these points with resultant short circuits. The age of a transformer appears to have but little effect upon its trouble rate except on sizes of 5 kva and less; also the newer transformers are less susceptible to lightning troubles than the older ones. Therefore, a reduction in trouble should result if the smaller transformers be replaced by larger ones or by ones of like size of recent design.

Arrester and Fuse Protection

Analysis of arrester performance, neglecting transformer size, has shown consistently during the past 5 years that arresters apparently effected little reduction in trouble. However, the same data, when analyzed with respect to transformer size, based upon cases of trouble on various size-groups, indicates that

Based upon "Distribution System Lightning Studies by Philadelphia Electric Company" (No. 32-20) presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932.

ansformers having capacities of 15 kva or less were ot benefited materially, but that those of more than 5 kva capacity showed a considerable reduction in ouble. (See Fig. 12.) The apparent poor performance of arresters on small transformers may be ue to the relatively low voltage breakdown of transformer leads to case resulting from small clearances; e breakdown voltage of the transformer leads may pproach too nearly that of the arresters. It is beved this applies particularly to the older transformers.

Fuse size has an important bearing upon the numer of fuse blowouts during lightning storms. In the

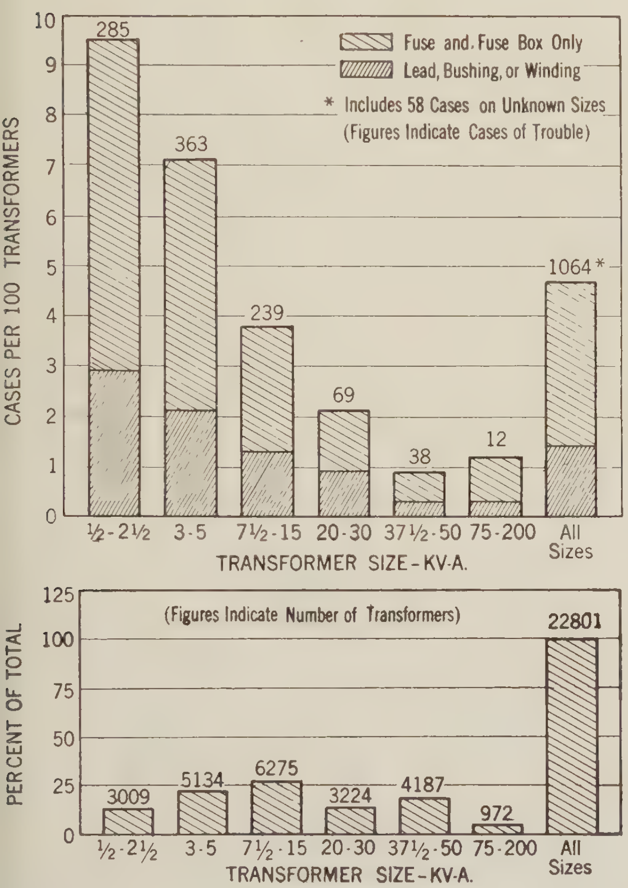

Fig. 11. Fuse and transformer lightning troubles on aerial portion of Philadelphia Electric Company distribution system (above) compared to number of transformers in service (below)

iladelphia division and in the area served by isquehanna Utilities Company these troubles were duced materially by changing from small to large ses; no appreciable increase in transformer failures sulted from this change. Former practise was to otect against overload by fusing at 1 amp per kva transformer capacity. At present, fusing against ort circuit is general practise throughout the stem.

GHTNING STORM SEVERITY; SHIELDING

Approximately 45 per cent of the total distribution stem lightning trouble for 1931, up to September 1, occurred during one storm (July 14) although there were 20 or more other storms during this period. This, with similar experience in previous years, indicates the number of storms to be an unsatisfactory measure of over-all lightning severity for any given year. At present, practical methods for measuring lightning severity are not available. It is desired to stress the need of suitable devices for this purpose.

Regarding "exposed" and "unexposed" locations, thus far it has not been found possible to establish any satisfactory relation between trouble experienced from lightning, and shielding provided by trees, tall buildings, or topography. However, it is felt that this may be a significant factor, since where shielding prevails, less lightning trouble is likely to result.

EFFECT OF GROUND RESISTANCE

Theoretically, the lower the arrester ground resistance the greater will be the reduction in surge voltage while the arrester is discharging. This fact, together with the favorable performance of arresters where ground resistances have been reduced to about 15 ohms or less on this company's 13.2-kv lines, is largely responsible for the effort directed toward improving grounds.

Measurements of single driven grounds widely distributed throughout the system indicated an average ground resistance of the order of 100 ohms. Accordingly, consideration was given in 1931 to the following methods of improving grounds:

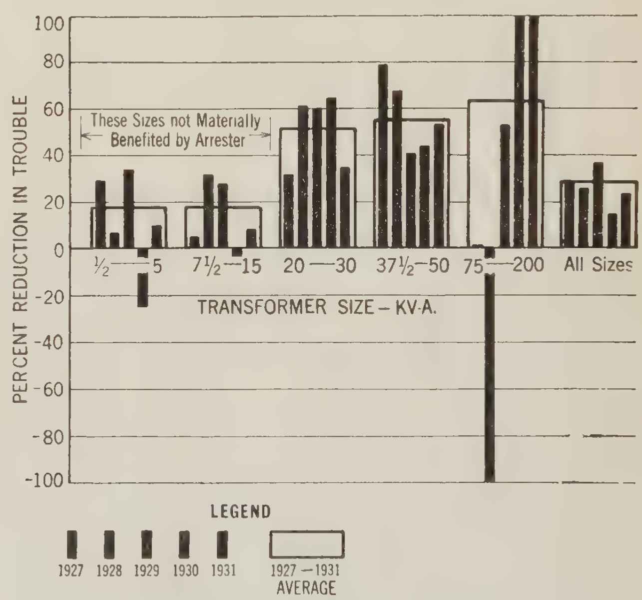

Fig. 12. Reduction in distribution system troubles effected by primary lightning arresters

1. Salt treatment.
2. Multiple ground rods.
3. Connection to water system.
4. Connection to secondary circuit grounded neutral.

Methods 2 and 4 were experimented with as discussed in the following paragraphs.

Multiple Ground Rods

In northeast Philadelphia where lightning trouble was serious, 345 installations of ground rods in multiple with existing arrester grounds were completed in July 1931. With a maximum of 4 additional rods per installation, it was possible to reduce 45 per cent of the grounds, many of which originally exceeded 50 ohms, to less than 15 ohms; all were reduced to less than 50 ohms. Up to September 1, 1931, 8 cases of trouble had occurred at these locations. Of these 8 cases, 7 occurred where the ground resistances exceeded 15 ohms. Expressed as troubles per 100 transformers, these data indicate only 13 per cent as much trouble where ground resistances were less than 15 ohms, as where ground resistances were higher than that value. However, this experience covers but a very short time and hence the results cannot be considered conclusive.

Multiple rods were installed also in an area outside of Philadelphia where lightning troubles had been even more serious than in the Philadelphia division. In that area 266 installations of multiple rods were completed in June 1931. While essentially the same reduction in resistance was obtained as in Philadelphia, experience in the 2 situations differed to the extent that the trouble rate was the same for ground resistances both above and below 15 ohms. This apparent difference in arrester performance in the 2 areas is believed to be due to the relatively small transformers in the area outside of Philadelphia, averaging about 4 kva in capacity compared with an average of 15 kva in Philadelphia. As previously discussed, studies have shown that but little protection can be obtained for the small transformers.

Connection to Secondary Grounded Neutral

Because of its low cost and added advantage of tending to equalize surge potentials on both primary and secondary sides of transformers during arrester discharges, connection between the primary arrester ground wire and the secondary circuit grounded neutral has been studied. Trial installations of this connection, hereafter called the "neutral tie," were completed early in June 1931 at 151 locations, involving 179 transformers. (See Fig. 13.) For comparative results these were concentrated in an area adjacent to where multiple rods were installed in Philadelphia, and in which lightning trouble had been equally severe. The use of the neutral tie was restricted to locations where the secondary neutral ground resistance measured less than 15 ohms and where the secondary circuit fed 10 or more customers whose service neutrals were grounded to water pipes.

Up to September 1, only one case of trouble, a transformer fuse blowout, occurred at neutral tie locations. This trouble was not accompanied by trouble on the secondary circuit or customers' equipment. Protected transformers in this area without the neutral tie had approximately the same rate of trouble. Unprotected transformers experienced considerable trouble, indicating that this area had been exposed to lightning storms of at least moderate severity. Although this experience over a short period of time indicates the feasibility of the neutral tie, observations over a long time and with a larger number of installations must be obtained before dependable conclusions can be drawn.

Analysis of customer meter trouble due to lightning during one severe storm indicated less trouble on secondary circuits fed from transformers with the neutral tie than on those from unprotected transformers. This indicates the neutral tie did not aggravate secondary trouble and, therefore, imposed no additional hazard on person or property.

Relation of Primary to Secondary Troubles

To determine the relative magnitude of primary and secondary system troubles during lightning storms an analysis of these was made for the unusually severe storm of July 14, 1931. Troubles occurring during that storm were selected for study because there was an unusually large number of them and because information concerning them was concentrated in the records. Later the troubles during this storm were found to constitute approximately 70 per cent of the total 1931 primary system troubles

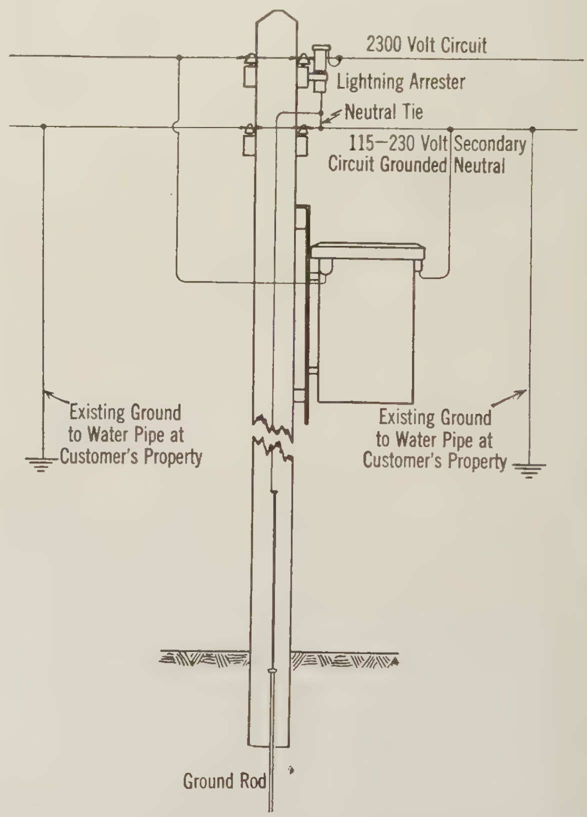

Fig. 13. Method of interconnecting arrester ground wire and secondary circuit grounded neutral; Philadelphia division

in Philadelphia. These troubles together with the estimated number of resulting customer interruptions are summarized in Table V. Correlating the 138 cases of customers' meter trouble with the cases of primary system trouble, shows that only 2 of the former occurred on secondary circuits fed by transformers experiencing primary trouble. Accordingly,

ondary circuit trouble must be due largely to dis-
rbances originating on that circuit.

It is evident from the causes of customers' inter-
otions that greater over-all improvement in service
ntinuity may be accomplished by attacking the
mary rather than the secondary situation. How-
er, from the viewpoint of the individual customer,
erruptions from secondary trouble are equally as
portant as those caused by primary trouble.
erefore, efforts should be directed also toward
lucing the secondary troubles.

IALYSIS OF CUSTOMER-HOUR INTERRUPTIONS

Primary circuit and individual transformer inter-
ptions exceeding 5 minutes in duration throughout
iladelphia and suburban divisions in 1931 to
ptember 1 were analyzed to determine the rela-
e magnitude of (1) those during lightning storms
d those during other periods; and (2) those due

ble V—*Primary and Secondary Trouble and Estimated Customer Interruptions Due to a Severe Lightning Storm

Classification of Trouble	Number of Cases	Estimated Customer Interruptions
nary System (2.3 kv)		
ransformer fuse and fuse box	69	4,140
ransformer winding	30	1,800
ransformer lead	27	1,620
rimary wires down	27	16,200
	153	23,760
ondary System (115/230 volts)		
ustomers' service fuses blown	1,200	1,200
usomers' defective apparatus, appliances, cords, and wiring	300	300
leters damaged	138	138
utside (external to service connections)	90	90
ervice pipes	2	2
	1,730	1,730

or Philadelphia division only; excludes service lost due to circuit inter-
tions at substations.

ectly to lightning disturbances and those due to
her causes, such as wind, trees, etc., during light-
ng storms. Results of this analysis are shown in
g. 14 where interruptions are expressed in customer-
urs and classified according to character of trouble.
ese results show that (1) of the customer-hour
terruptions exceeding 5 minutes from all causes,
ore than 80 per cent occurred during lightning
orms; and (2) of those during lightning storms, at
ist half are due directly to lightning disturbances.
appears, therefore, that protection of distribution
stems against lightning is of major importance in
ttering service continuity.

MMARY AND CONCLUSIONS

From the foregoing experience, the following con-
isions are reached:

Annually about 5 per cent of the 23,000 aerial distribution
nsformers experienced trouble in some degree due to lightning.
all transformers have been found more susceptible to lightning dis-
bances than large ones. As far as practicable, the larger trans-
mers should be used, or the older units replaced with more recent
s of the same size.

Differences in susceptibility between transformers of different
sizes must be recognized when analyzing arrester performance. Observations over 5 years show little benefit from arresters when considering transformers of all sizes collectively. However, taking size into account, these same data indicate that arresters afforded little benefit to those of 15 kva and less capacity, but substantial benefit to the larger sizes.

3. Many factors influence lightning trouble on distribution systems. It is important to consider all of the major ones if reasonable conclusions are to be reached. Also, to permit comparisons with other

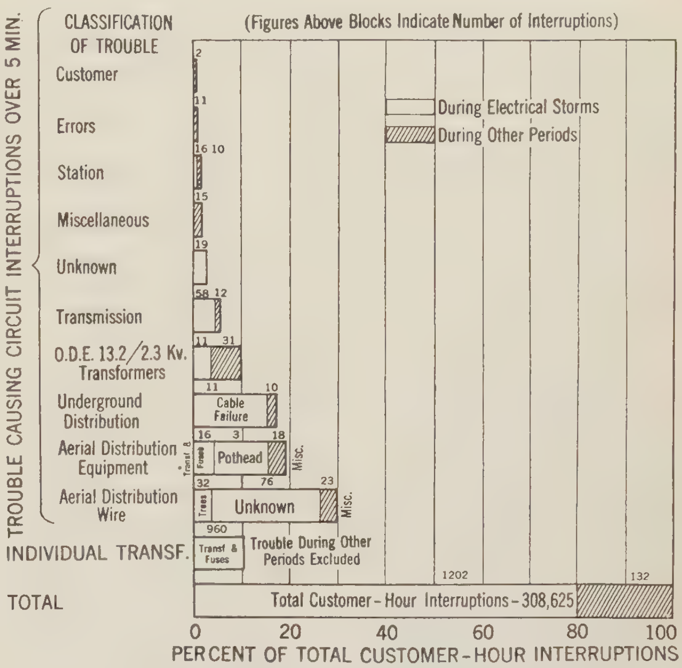

Fig. 14. Estimated customer-hour interruptions due to primary distribution system outages for the first 8 months of 1931; estimates are for Philadelphia and suburban divisions

studies, it is important to have data reduced to a common basis. One method is to compare performance per 100 transformers.

4. Because of the many factors involved, it has not been possible thus far to determine whether there is a material difference in susceptibility to lightning trouble on grounded and ungrounded systems.

5. Low ground resistance, which theoretical and field studies show to be essential to effective arrester performance, may be obtained at low cost by connecting the arrester ground wire to the secondary circuit grounded neutral; however, where this is done, secondary neutrals should be grounded effectively. Limited field experience shows that this method furnishes satisfactory protection against transformer failure without introducing additional troubles on the secondary system.

6. Customer interruptions from trouble on the primary system far exceed those from trouble on the secondary system. Therefore, major improvement in service continuity can be accomplished best by attacking the primary situation. However, service reliability as measured by the customer is independent of the source of trouble, and consequently improvements on the secondary system cannot be neglected.

7. The number of customer interruptions of a duration less than 5 minutes greatly exceeds those of more than 5 minutes. However, based upon customer-hour interruptions, the latter greatly exceeds the former.

8. The majority of customer-hour interruptions from all causes occur during electrical storms. Of these, this study shows that at least half are directly attributable to lightning disturbances.

9. In the interest of improving service continuity, lightning protection of distribution systems has been found to be of major importance and can be justified economically only from this point of view. Minimizing inconveniences to customers, although of intangible value, nevertheless is highly important and should be carefully considered when establishing policies and practise in solving the lightning protection problem.

Kaplan Turbines at Safe Harbor Hydroelectric Plant

One of the numerous features of more than usual interest of the Safe Harbor hydroelectric development is the use of Kaplan turbines having automatically adjustable blades. This type of turbine is used in all of the 6 units of the initial installation, each rated at 42,500 hp under a rated head of 55 ft. Engineering studies in connection with these units required the construction of a new hydraulic laboratory for testing model turbines.

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MANY new and interesting problems arose in connection with the design and installation of the Safe Harbor turbines. As in any pioneering development of this magnitude, an unusual amount of experimental and engineering study was necessary involving not only the hydraulic and mechanical design of the plant but affecting the structural and electrical design as well.

Limited experience in this country with propeller type turbines caused the Safe Harbor management to feel that certain important operating and engineering information was essential to justify a large expenditure in this comparatively new type of turbine. This feeling was intensified by the fact that the manufacturers had to build wheels considerably larger than had been built before. Furthermore, each of the various manufacturers had offered for consideration several different designs for which no comparative data as to cavitation limitations were available.

Final design of the power house structure depended upon the decision as to the elevation of the turbine runner. The position of the runner with respect to the tailwater elevation would affect materially the power rating of the turbine as limited by cavitation; obviously the economics of the power house substructure and excavation could be determined only after the power limits of the various runners were known. The absence of a hydraulic testing laboratory in this country in which cavitation tests coul be made led to the construction of such a laborator at Holtwood, Pa., adjacent to the Holtwood hydro electric plant.

Based upon "Safe Harbor Kaplan Turbines" (No. 32-124) to be presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932.

Why Kaplan Turbines Were Adopted

During the early engineering studies an investiga tion was made of the various types of turbine

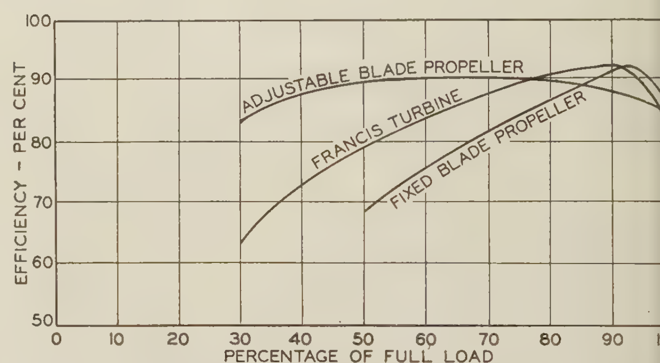


Fig. 1. Comparative efficiencies of 3 types of turbines

9,500-hp turbines operating under a head of 38 ft; adjustable blade propeller running at 164 rpm.; fixed blade propeller, 150 rpm; Francis turbine, 100 rpm

suitable for the Safe Harbor development which has relatively low operating head, limited storage, wid fluctuations in river flow and operating head, and wher peak load rather than base load is of prime importanc

Appreciable savings in the cost of power hous structures were found possible by using the propelle type of turbine of either the fixed or adjustable blad type. Further savings in the cost of the electri generators were obtainable with propeller turbine because their higher speeds permitted the use o smaller and consequently lower cost generators an direct connected exciters. (See "Hydraulic an Electrical Possibilities of High Speed, Low Hea Developments," by Jessop and Powel, A.I.E.E TRANS., v. 50, 1931, p. 114–9.)

The automatically adjustable blade propelle turbine has certain additional advantages over th fixed blade propeller type: It has a high efficienc over a greater range of loads (see Fig. 1); it can b operated considerably above its normal power ratin for short periods of time without an appreciable los in efficiency; it has materially greater output whe operating under reduced heads; it is more stabl when operating at part loads. However, on accoun of the additional mechanism required for blad adjustment, Kaplan turbines are more expensiv both in first cost and in maintenance.

The final decision to use Kaplan turbines in *all* of ie initial units, rather than using 1 or 2 Kaplan units ıd fixed blade propeller turbines for the others ɛsulted from a consideration of the operating ɛquirements of this plant. With a run-of-river ɫant such as Safe Harbor where the maximum disıarge of the initial 6 units will be approximately),000 cfs, which flow is available for only about 3 ıonths in an average year, the plant obviously will ɔerate as a peak load plant for the greater part of ıe time. Such operation involves rapid changes in ɔad. During extreme low-flow seasons, when the ɛservoir will be drawn down on a periodic schedule, ıere will be a wide variation in the operating head ı the plant. When the normal river flow is less ıan the usable flow through the plant, water is aluable and high operating efficiency at part load is ɛsirable, for water thus saved replaces steam capacity s well as steam energy on the system.

High part-load efficiencies are particularly imɔrtant on a system where the spare capacity may be ırried at the hydro plants. Furthermore, the Safe Harbor plant soon will be the point of interconnecon of several major electric systems and undoubtɛdly there will be periods when split bus operation ill be expedient. With such operation Kaplan ırbines are the more economical. Maximum efciency at full rated load is not essential, since during ɔw river flow rated output would be required for but ıort periods, while at high river flow, when there is ı abundance of water, efficiency is not important. Iaximum output for short periods and particularly ɯring flood conditions when the back water maɛrially reduces the operating head at the plant is of articular value. Maximum operating economy and exibility could best be obtained by using turbines ɫl of the Kaplan type. Certain further advantages ɫways accrue through the use of a single size and ɣpe of unit in any plant as it requires a minimum of ɔare parts to be carried, and minimizes hazards ɔom operation and maintenance.

Description of Unit

A cross section through one of the Safe Harbor ırbines is shown in Fig. 2. The runner of the ırbine is 220 in. in diameter and has 5 blades. hese blades can be rotated about a horizontal axis ɔom approximately a horizontal position for no load ɔeration, to an angle of 30° for maximum loads. he throat ring is spherically shaped to permit this ıovement with a minimum of clearance between ɫades and ring, reducing the amount of leakage.

Operating mechanism for changing the blade angle ɔsition is located in the hub and hollow shafting of ıe wheel. Each blade is connected through a link a main head in the runner hub which is connected y an inner shafting to a large "servo-motor" located ıst below the unit thrust bearing. Oil pressure ɔtained from the main governor system is carried this servo-motor through the "Kaplan head" ɔn the top of the generator shaft) from the operating alve shown at the right of the main unit. An ɛtuating rod connects the wicket gate operating ng with this valve to maintain a definite predetermined position of runner blade for each wicket gate opening. The correct relationship between gate opening and blade angle was found from tests, and is maintained by a specially shaped cam interposed in the actuating rod between the gate operating ring and the runner blade operating valve. This cam can be changed readily for variations in operating head inasmuch as to maintain best efficiency requires a different relationship for each head.

The intake section of the unit has a horizontal floor constructed at the same elevation as the river bottom in the forebay; side walls are parallel and the roof is bell shaped at the entrance. The center line of the turbine was offset from the center line of the intake 2.0 ft for reasons discussed later. The elbow draft tube has a V-shaped roof toward the discharge end, and an appreciable angle of upturn in the horizontal leg to reduce to a minimum the amount of tailrace excavation.

Holtwood Hydraulic Laboratory

The hydraulic test laboratory at Holtwood, Pa., was designed for testing model turbines 16 in. in diameter (approximately $^1/_{14}$ the size of the actual Safe Harbor units) with complete wheel setting and water passages including intake, scroll case, wheel casing, and draft tube, under a range in test head varying from 4 to 60 ft. For cavitation tests the

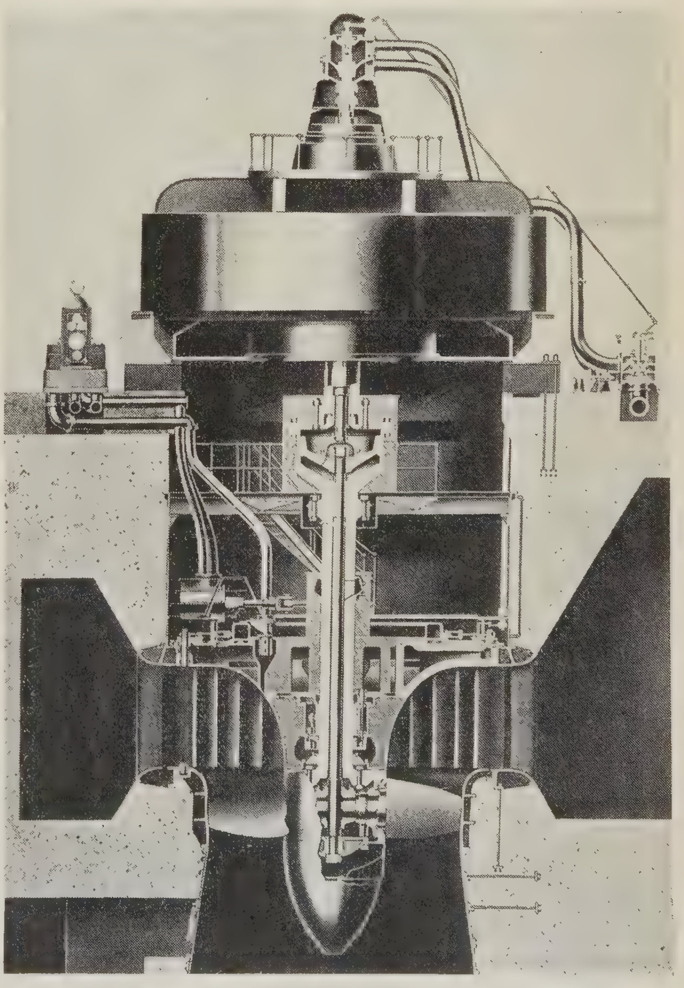


Fig. 2. Cross-section through a Safe Harbor turbine

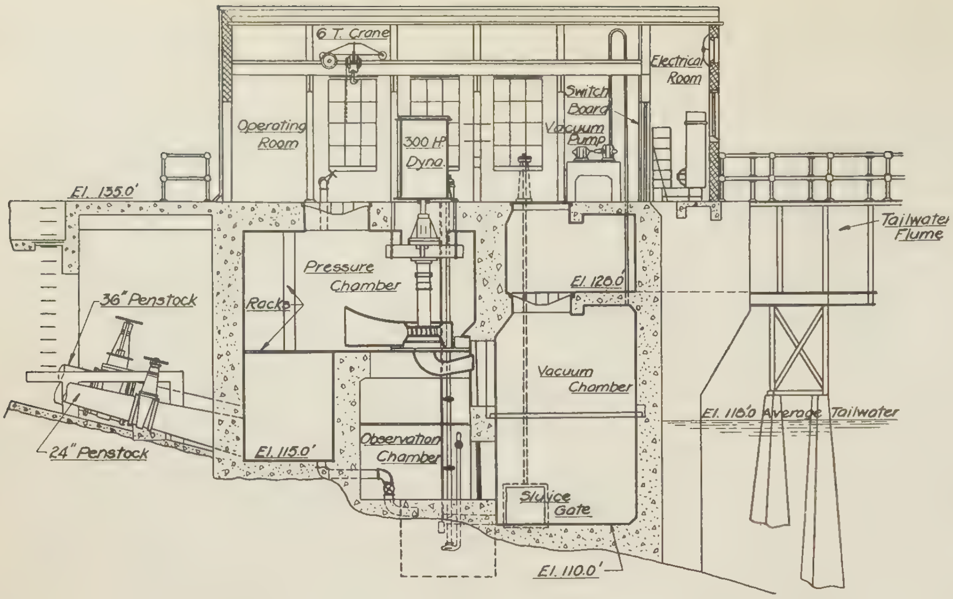


Fig. 3. Longitudinal section of Holtwood hydraulic laboratory

draft head may be varied from approximately 10 ft pressure head to 10 ft suction head. A cross-sectional view of the laboratory may be seen in Fig. 3.

The maximum head at the Holtwood plant is slightly less than 60 ft, but since, for cavitation tests it is necessary to vary the suction head over a wide range while holding the total head the same, it was found impossible to get the desired range of heads by using the available drop between the Holtwood forebay and tailrace. A high-head tank therefore was built, into which water can be pumped to an elevation approximately 20 ft above the normal level in the Holtwood forebay, for which purpose a 20,000-gpm constant-discharge pump is used. The water in excess of the amount required in the laboratory is bypassed back into the Holtwood forebay by means of a sluice gate operated by remote control from the main laboratory. By manipulating this sluice gate any desired forebay elevation may be quickly obtained and held constant. From this tank the water flows through a 36-in. penstock to the pressure chamber in the laboratory. After entering, the water must pass through a series of baffles which remove whirls and eddies and insures uniform velocity distribution as the water approaches the intake passages of the turbine. The pressure chamber was designed sufficiently large to accommodate the complete wheel setting. Water passes from the draft tube into a vacuum chamber, so called because a vacuum pump connection permits operating this chamber under either positive or negative pressure as required. The water finally discharges through a sluice gate at the bottom of the vacuum chamber, or may be allowed to enter the chamber above the vacuum chamber from which a flume carries it to a sharp-crested weir.

Because of the wide range required in tailwater elevation, it was impractical to use a weir regularly for measuring the laboratory discharge. A 36x15-in. Venturi meter was installed in the main penstock for measuring the water flow; connections to this Venturi meter were brought into the laboratory so that the discharge may be measured in the main laboratory.

Power developed by the test turbine is absorbed by an electric dynamometer mounted on the laboratory floor above the pressure chamber, rated at 300 hp when used as a generator, but also designed to develop 225 hp for operation as a motor for proposed pump tests. This dynamometer was designed specially for this installation and is the first one ever made for vertical mounting. Electrical output from the dynamometer is dissipated in grid resistors.

To facilitate the study of cavitation, the laboratory was laid out to permit visual observation of the water flowing in the draft tube just below the model runner. This has been accomplished by installing small glass windows in the tube. A chamber around the draft tube affords a point of observation for watching the formation of cavitation and the general behavior of water in the vicinity of the runner.

Cavitation Limit of a Turbine

As previously stated it is of utmost importance to place the turbine runner at the proper elevation with respect to the tailwater surface. If any type of waterwheel is too high above the tailrace, the vacuum formed under the runner blades may cause cavitation, which can result, in addition to a serious loss of efficiency, in the destruction of the runner and draft tube by pitting. Pitting is probably due to a combination of erosive and corrosive action.

Cavitation starts when the absolute pressure at any point in the water column approaches the vapor pressure of the water, which pressure is, of course, very near absolute vacuum. In propeller turbines the velocity of the water is maximum and consequently the pressure minimum where the water passes through the runner. The exact location of minimum pressure depends upon the runner design. If this low pressure is below the vapor pressure at any point along the blade surface, the water will have a tendency to leave the surface of the blade forming a void; such voids will be filled quickly with a mixture of water vapor and air removed from the adjacent water by "cold boiling." The surface of separation between the flowing stream and the eddying region left by the separation may be shown theoretically to

essentially unstable; hence, sudden breakdowns the cavities rapidly recur, having the effect of ntinuing explosions, resulting in intense hammer tion in the pores of the metal. Eventually such tion erodes the surface of the runner blades. addition to this erosion it is probable that oxygen, hich is released readily from solutions at very low essures accumulates along the surface of the runner ades, and attacks the steel surfaces, especially here the metal has been attacked previously by osion.

Cavitation can be practically eliminated by setting e runner sufficiently below the tailwater level to sure that the minimum pressures along the blade rfaces are well above the vapor pressure. For onomic reasons it is important to determine acrately the maximum elevation at which the runner ay be set so as to reduce to a minimum the exnsive excavation work for the draft tube and ilrace.

Tests on a complete model of the Safe Harbor take, scroll case, wheel setting, runner, and draft be were made to determine within close limits the ghest elevation at which the runner could be set thout danger of serious cavitation for the maxium turbine power desired. Fig. 4 shows the sults of a typical test made for determining the lue of draft head at which cavitation starts. ficiency, power, and discharge of the turbine have en plotted against a coefficient called Σ (sigma). ie term Σ first introduced by Professor Thoma of ermany is derived as follows:

eoretically cavitation starts when the absolute pressure on the ner is equal to the vapor pressure of water; therefore

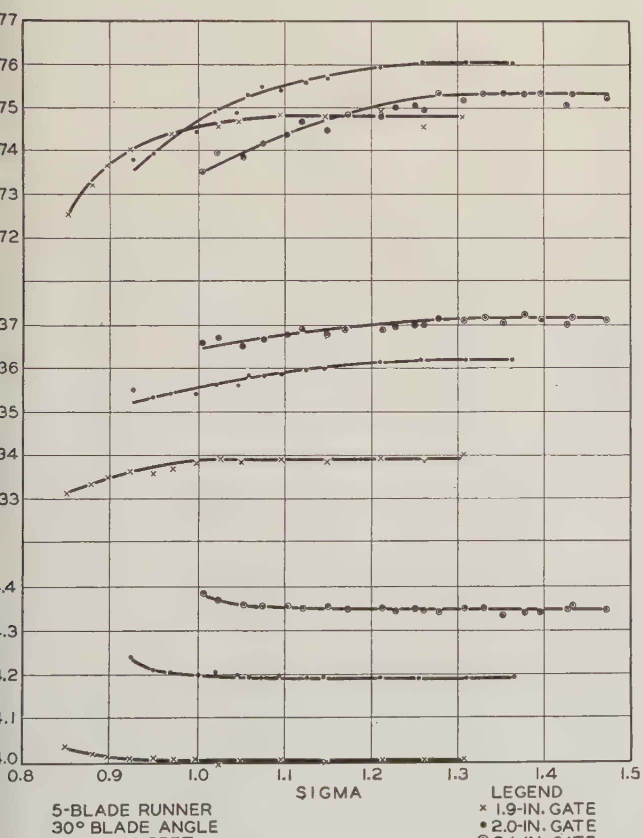


Fig. 4. Typical cavitation curves for a model turbine

$$H_B - H_D - \frac{\Sigma V^2}{2g} = H_v \qquad (1)$$

where

H_B = Barometric pressure in feet of water at the surface of the tailwater
H_D = Draft head (elevation of runner minus elevation of water surface in tailrace)
Σ = Coefficient
$\frac{V^2}{2g}$ = Velocity head at the blade surface
H_v = Vapor pressure of water

$\frac{V^2}{2g}$ varies directly with H_T, the total net head on the runner.

Therefore eq. 1 may be written

$$\Sigma = \frac{H_B - H_D - H_v}{H_T} \qquad (2)$$

Laboratory procedure in determining the cavitation limit for a definite blade angle and gate opening was to start with a high tailwater elevation and make a series of tests with gradually decreasing tailwater level maintaining for each series a constant total head and a constant speed. The value of Σ at which efficiency and discharge were found to break, was taken as the cavitation limit for that particular speed, head, and gate opening. Similar tests were made for each combination of head, gate opening, and blade angle. From the results it was possible to predict the cavitation limit of a model runner for various operating combinations of draft head and total head. From an operating standpoint it was essential to establish the limits of power output for a wide range in both draft head and total heads.

Model Tests of Draft Tube Design

Correlated with the study of the cavitation limits of a turbine, and the economics of determining the proper runner elevation, is the problem of draft tube design. A draft tube with the shortest vertical section usually will be the least expensive, as minimum excavation will be required not only under the power house substructure but also in the tailrace below the power house. A review of European experience together with theoretical considerations of water velocities through a Kaplan runner led to a decision in favor of an elbow type of tube.

Each of the turbine manufacturers submitted alternate designs of elbow tubes, all of which were tested in the Holtwood laboratory with the Safe Harbor model runner, to obtain comparative data on the relative efficiencies and operating characteristics. These tubes differed in the following general features of design:

1. Angle of flare in the vertical section just below the runner.
2. Length of the vertical section (distance between centerline of runner and lowest point of the tube).
3. Location and area of the draft tube "throat."
4. Shape and angle of divergence near the discharge end of the horizontal section.

The final design chosen (see Fig. 5) was determined not only from a consideration of the maximum efficiencies obtained, but also with due regard to the shape of the horsepower-efficiency curves, in order to obtain a curve as flat as possible for each blade angle position, thereby eliminating any possibility of

instability resulting from sudden changes in load. An appreciable amount of excavation was saved by turning the whole tube upward through an angle of 9°; it was found that this could be done without sacrificing either efficiency or power.

Model Tests of Scroll Case Design

A series of scroll case tests were made in the laboratory, before deciding upon the final design, to determine whether any advantage is realized by offsetting the center line of the runner shaft from the center line of the intake, thereby increasing the cross-sectional area of the scroll and reducing the velocity of the water. The results indicate that if for the unit spacing used at Safe Harbor, a speed ring with a relatively large diameter was used, a quite noticeable saving in efficiency and power could be obtained; if, however, the fixed guide vanes of the speed ring were of narrow proportions and the speed ring of smaller diameter, no improvement was found in either efficiency or power.

Scroll cases of the Safe Harbor turbines were designed eccentric, however, even though the speed rings were of relatively small diameter. This decision was made to permit maximum flexibility in the design of the wheel settings for all future units of the plant.

Power and Efficiency Tests

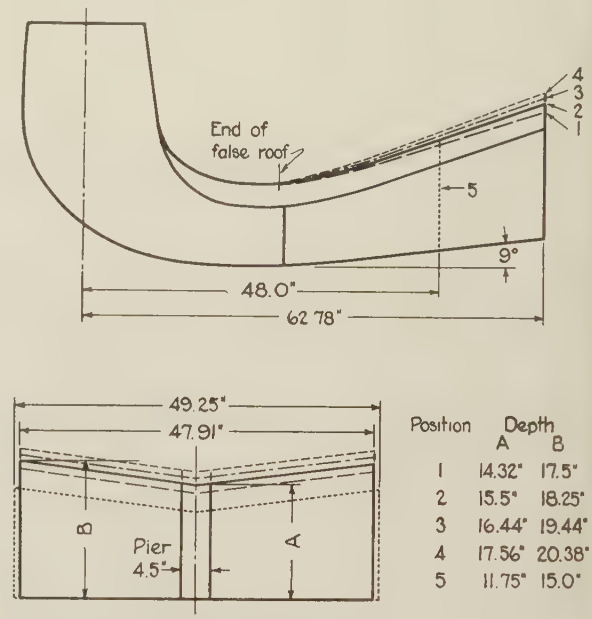
Comparative power and efficiency tests on each of the numerous turbine designs submitted were made at the Holtwood laboratory, all tests being made with a complete turbine setting, including intake, scroll case, and draft tube. These tests were made under a head approximately equal to the field head at Safe Harbor (about 50 to 55 ft) and in each case were conducted in the presence of a representative of the manufacturer whose runner was under test. At the completion of the tests the manufacturers were given the opportunity to revise their guarantees of power and efficiency on their respective turbines. Some of the guarantees for the final Safe Harbor units are shown in Fig. 6.

Curves giving the results of a typical test are shown in Fig. 7. The range in values of Φ covered corresponds to a variation in head of from 32 to 60 ft, although the actual testing was done under a constant head and varying speeds. Tests were made at various blade angles to obtain an envelope curve representing the maximum efficiency obtainable for the proper operating relationship between blade angle and wicket gates; as previously described this relationship is maintained on the actual units by means of a cam in the blade operating mechanism.

Field Tests

To insure that the units are properly adjusted and are operating to give the best possible efficiency, numerous field tests and inspections were planned. A small amount of cavitation probably is permissible since the steel blades of the turbine are quite shock-resistant; therefore it was decided to operate the units slightly beyond the point where cavitation started in the laboratory, and study carefully the effect on the runner blades and draft tube.

During the first few months of operation the turbines were inspected about every 2 weeks. Now that the plant has been in operation some time, these inspections are made about every 6 weeks on each unit. It has been found that on certain portions of the runner blades paint was removed. In addition a small area on both the top and bottom blade surfaces at the leading edge near the periphery seemed to be subject to local cavitation. Minute hollows and reversals in curvature attracted cavitation, and eventually pitting took place. However, by slightly reshaping the leading edge of the blade so that it was sharper, and making an exceedingly gradual transition from the nose to original blade surface from 6 to 8 in. back from the leading edge, this local cavitation was largely eliminated. This area probably always will be susceptible to cavitation, and consequently it is of the greatest importance to have a very smooth surface, free from reversals in curvature. One unit



Position	Depth A	Depth B
1	14.32"	17.5"
2	15.5"	18.25"
3	16.44"	19.44"
4	17.56"	20.38"
5	11.75"	15.0"

Fig. 5. Various modifications of the Safe Harbor draft tubes studied at the Holtwood laboratory

Dimensions are for the model tube

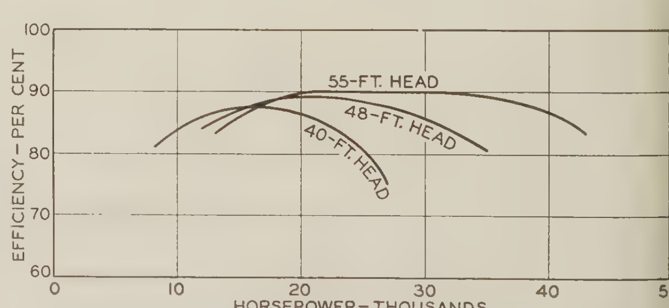


Fig. 6. Guaranteed horsepower-efficiency curves for a Safe Harbor turbine running at rated speed of 109.1 rpm

s held at a power output limit well below the nt where cavitation started on the model. The nt erosion on this unit was less than on the other its, but the local pitting was of about the same gnitude, and in the same place.

On the underside of the blades near the trailing ge, an area has been attacked by slight cavitation

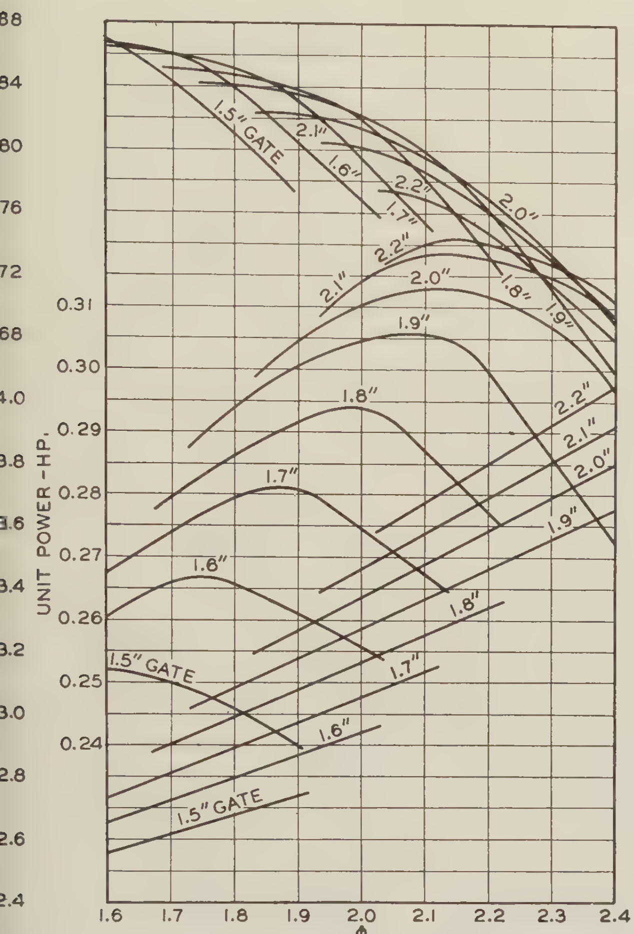


Fig. 7. Typical efficiency curves computed from test results on a model turbine; blade angle 22°

Φ is the ratio between peripheral speed of the runner and spouting velocity for the head in question

a magnitude sufficient to remove the paint, but as t there is no indication of pitting. It is interesting note that rust has covered these areas in spite of cavitation.

To establish the most efficient relationship between e opening and blade angle, it is not necessary to asure the actual efficiency or discharge; it was cided to establish this relationship by the use of an ex method. At various points in the scroll case d on the wheel setting 7 piezometers were installed ring the construction of the plant. At the time of turbine efficiency tests these piezometers will be ibrated and a meter ultimately will be installed integrate as well as indicate the discharge through turbines. It is proposed to have a meter on each t. A totalizing meter will be installed in the trol room to indicate the total discharge through plant.

Methods of testing hydroelectric units commonly used in this country have been found inadequate on most low head developments where large quantities of water are to be measured, because of the shortness of the approach passages to the unit. In Europe, current meters have been used for many years in making efficiency tests, and have been found particularly well adapted for use on low head developments. Several turbine efficiency tests have been made in this country with current meters, but on such tests only a few meters were employed; the results usually have been of doubtful accuracy. It was decided at Safe Harbor to follow the European method of making current meter tests and to employ the Ott meter so generally used abroad.

One difficulty encountered in making current meter measurements is the time required to traverse the area of the metering section properly. It was found that a great many metering points would be necessary for each horizontal traverse. Therefore 27 current meters of the spoked-wheel type were purchased; these were mounted in the same horizontal plane on a rack made of stream line rods. This rack can be lowered in the gate slots to any desired elevation for obtaining a vertical traverse.

It was recognized that the Ott spoked-wheel current meter consistently under-registers for angular flow. The metering section at the gate slots is just at the end of the bell-mouth so that there obviously would be considerable angular flow near the top of the metering section. To obtain accurate measurements in that area, 27 conical screw propeller current meters were purchased and mounted on the same current meter rack 6 ft above the spoked-wheel meters. It was found that the difference between the indicated velocities of these 2 types of meters increased uniformly with an increase in the angle of flow; thus for a given difference in observed velocity on the 2 types of meters the true angle of flow could be determined readily and a proper correction could be applied to obtain the true velocities passing the metering section.

Conclusions

The test program conducted in coordination with the plant design has resulted in numerous improvements in operating performance, has effected savings in construction costs, and has permitted a more complete study of the behavior of the Safe Harbor units. Such a program eliminated to a large degree the necessity of relying too greatly upon the limited field experience available. No little part of the success of this program depended on the close cooperation of the engineers of the 2 turbine manufacturers who for the first time in hydroelectric development in America, jointly developed and manufactured turbines of identical design wherein practically all replaceable parts are interchangeable.

The first 6 months of actual performance indicates that the prediction of the cavitation limits for the turbines based upon the laboratory model test results are reasonably close, although a longer period will be necessary to establish *definitely* a close correlation between laboratory and field results.

News

Of Institute and Related Activities

Vancouver Convention Upholds Coast Reputation

AS THE OCCASION of his first formal public appearance as president of the A.I.E.E., H. P. Charlesworth opened the 21st Pacific Coast convention of the Institute at the Hotel Vancouver, Vancouver, B. C., Tuesday morning, August 30, 1932.

Preceding Mr. Charlesworth was Mr. W. G. Murrin, president of the British Columbia Electric Railway Company, Ltd., who was introduced by the convention chairman, G. R. Wright. Mr. Murrin stressed the great value and importance to human welfare of the free and wide interchange of technical knowledge concerning the practical application of the fruits of scientific research, regardless of international or selfish boundaries. Of the 3 common media of such exchange—direct correspondence, the technical press, and the personal contacts and discussions possible only through conventions and technical meetings—the speaker urged increasingly serious attention to the latter.

In his brief response of appreciation for the official welcome, Mr. Charlesworth referred to the remarkably rapid advances that have been made in science and engineering expressing the belief that further progress is inevitable. Citing from the broad field of electrical engineering such examples as the modern facilities in transportation by land, sea, and air; in communication by wire and by radio; and in the applications of electric power devices that constantly are reducing the drudgery of factory, office, and home, the speaker pointed out that all of these must of necessity have a profound effect upon our daily life. In consequence, engineers, individually and collectively were pointed out as having in addition to obvious technical duties, a very real and human responsibility in sociological matters ranging all the way from local civic interest to national government.

A pleasant surprise to all, and a fitting tribute to the unremitting year-long efforts of the committees in charge, was the attendance of 300 persons. Every Section in the far-western Districts was represented as were also 13 out of the 14 Student Branches. In addition to President Charlesworth, Institute officers present included vice-presidents A. W. Copley of San Francisco, Calif., C. R. Higson of Salt Lake City, Utah, and L. B. Chubbuck of Hamilton, Ont., Canada. The attendance is analyzed in an accompanying tabulation.

Technical Sessions

The technical sessions featured the 14 papers listed on p. 519 of Electrical Engineering for July 1932, each paper drawing its share of discussion. They were divided among 4 sessions devoted in general to power generation; transportation, electrical machinery, and metering; station apparatus; and communication and power transmission. Presiding over these meetings, respectively, were A. W. Copley, H. V. Carpenter (past vice-president), L. B. Chubbuck, and C. R. Higson.

Table I—Analysis of Attendance at 1932 Pacific Coast Convention

	Location				
Classification	Vancouver	Dist. No. 9	Dist. No. 8	Misc.	Totals
Members	66	41	21	7	135
Men Guests	59	4	2	1	66
Women Guests	28	16	12	3	59
Students	16	11	10	3	40
Totals	169	72	45	14	300

In addition to the foregoing, 2 student sessions were held, one with the gavel in the hand of F. C. Carmen, chairman of the University of Utah Branch, and the other under the direction of W. D. Hudgins, chairman of the University of California (Berkeley) Branch. At these sessions the following papers were presented:

Electrical Properties of Hardened Copper, A. J. Hill and Homer Lambkin, Montana State College.

Steam Versus Electric Drive for Sawmill Operation, E. A. Buckhorn, Oregon State College.

Electrical Reflections in A-C Machinery, D. J. Moore, University of Washington.

Comparison of Two Methods of Calculating a Transmission Line, Duane Olney and N. A. Miyota, Washington State College.

Effect of Atmospheric Conditions on Corona Loss, Victor Siegfried, Stanford University.

Short Circuit and Arcing Characteristics of Renewable Link Cartridge Fuses, Louis Bayha and Oliver Jesson, University of Southern California.

A Stroboscopic Device for Studying Rotary Motion, Kenneth Nielsen and W. S. Nishiyama, University of Utah.

Investigation and Application of the Ultra-Short Waves in Radio, J. H. Russell and J. A. O'Neil, University of Santa Clara.

The Parallel Type Inverter, Wilson McRae, University of British Columbia.

A Timing Instrument for Transients, Suitable for Measuring Time Lag of Spark-Over, Abe. Tilles, University of California.

The Design of an Efficient Amplifier Coupled to an Antenna, Sydney Sillitoe, University of Alberta. Read by H. Freedman, University of British Columbia.

Attendance at all technical sessions averaged by actual count well in excess of 100. The delegates and guests were invited to a special luncheon meeting of the Vancouver Electric Club to hear the address of Capt. E. A. Wheatley, registrar of the British Columbia Association of Professional Engineers, concerning the importance to engineers of their cooperating effectively in the control and application of engineering education.

Student Activities

In addition to the technical sessions already mentioned the Enrolled Students and their Counselors were the feature participants in a luncheon meeting held Tuesday, August 30, and a dinner at the University of British Columbia immediately preceding the annual student conference held there at 8 p.m., September 2, with Dr. J. H. Hamilton, counselor, University of Utah Branch, presiding. The meeting was opened by brief addresses by President H. P. Charlesworth and Vice-President A. W. Copley of the Pacific District, both of whom emphasized the importance of student activities in the further development of the Institute.

Of the 14 Branches in Districts 8, 9, and 10, eight were represented by their counselors and chairmen, and each of the others was represented by either the counselor or the chairman. Branch counselors present included: J. C. Clark, Univ. of Arizona; R. W. Sorensen, Calif. Inst. of Tech.; L. E. Reukema, Univ. of Calif.; N. C. Clark, Univ. of So. Calif.; J. H. Johnson, Univ. of Idaho; J. A. Thaler, Montana State Col.; E. C. Starr, Oregon State Col.; J. H. Hamilton, Univ. of Utah; O. E. Osburn, State Col. of Wash.; G. R. Shuck, Univ. of Wash.; and E. G. Cullwick, Univ. of British Columbia.

The Branch chairmen present included: Bruce Watkins, Univ. of Arizona; M. S. Hodge, Calif. Inst. of Tech.; W. D. Hudgins, Univ. of Calif.; J. H. Russell, Univ. of Santa Clara; R. R. Moore, Univ. of So. Calif.; G. W. Dunlap, Stanford Univ.; R. S. Stokan, Montana State Col.; R. J. Mather, Oregon State Col.; F. C. Carmen, Univ. of Utah; and P. W. Hand, State Col. of Wash.

Some of the topics of discussion were the desirability of the selection of the dates of future Pacific Coast conventions in order to secure Labor Day railroad rates, traveling expenses allowed for the conferences on student activities, and methods of providing for closer cooperation between the Uni

sity of British Columbia Branch and the anches in the North West District. The e-presidents of the Pacific and North est Districts were requested to appoint a nt committee to consider these matters d prepare recommendations.

Much interest was exhibited in the stunt technical papers presented at the contion, and there was a discussion regard- the mimeographing, and advance disoution of the papers prepared for future nventions.

TERTAINMENT

The social program, delightful in its simcity and satisfying in its variety, was ened formally by the reception for Present Charlesworth, with a subsequent nce held Tuesday evening. Women's ents included trips to various points of erest, an afternoon's outing in Vanuver's famous Stanly Park featured by and a pitch-and-putt golf tournament, d a bridge tea held Friday afternoon. inners of golf prizes were Mrs. C. Arnott Vancouver, B. C., and Mrs. H. O. Blair Tacoma, Wash.; Mrs. H. V. Carpenter Pullman, Wash., won a special prize for aking a hole-in-one on her initial round.

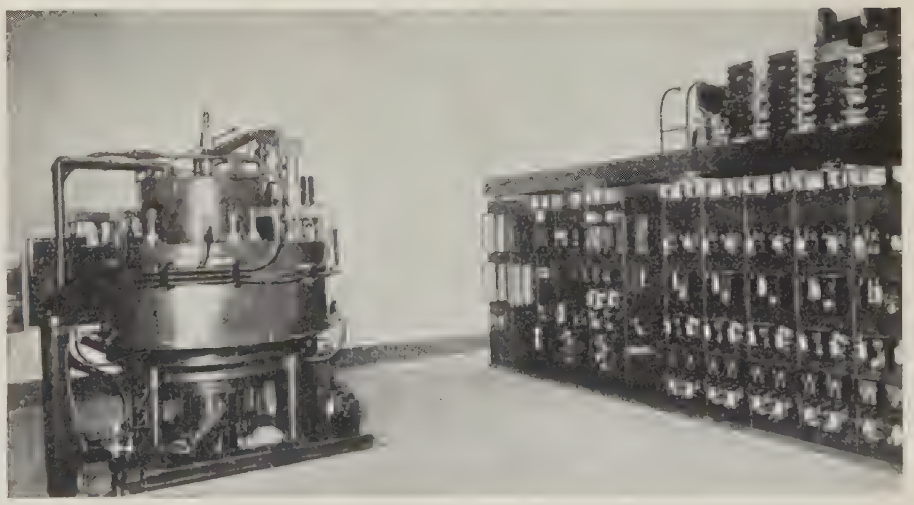
A 4-hour boat trip with dinner served oard drew 188 men and women out ednesday evening in spite of rainy eather. The trip was made on the Canaan Pacific steamer "Princess Norah." ne convention dinner held Thursday even- also proved to be an attractive affair, ere being some 240 persons in attendance. esident Charlesworth in addressing the nqueters briefly recalled one of the prinal motives of the Institute as being "the vancement of the theory and practise of ctrical engineering and its allied arts and ences, the maintenance of a high prossional standing among its members, and e development of the individual engineer." this connection he emphasized how well e Institute's conventions in general and e Vancouver convention in particular nctioned to maintain this underlying inciple of development regardless of litical boundaries. In part he said: Ve are indeed advancing effectively the eory and practise of electrical engineering rough the interchange of information . . .; o we are aiding the professional standing d development of our individual engiers. . . . Not only professionally but also rsonally do we gain from these meetings."

Concerning the much talked of matter of e engineer's place in our general socialonomic structure, Mr. Charlesworth said part: " . . . . Whether we are concerned th research, engineering, education, or y other branch of the profession, it is ident . . . . that we cannot but be called on to play an even greater part in the oblems attendant upon the application the results of our work, and, in fact, in the neral affairs of society. If we recognize ese opportunities, and individually and llectively do our full share, and if we fully preciate that we cannot approach these oblems alone as engineers, but rather llectively with all other groups of society, shall not only make a real contribution the solution of some of the difficult probns now confronting our individual counes and the world in general, but we shall have enhanced materially the prestige of our profession."

Following Mr. Charlesworth's address the amateur dramatic club of the British Columbia Electric Railway Company cleverly enacted a little skit entitled "The Mayor and the Manicure." Prizes for Institute papers as announced on p. 418 of ELECTRICAL ENGINEERING for June 1932, were presented by President Charlesworth; the presentation of golf prizes brought the evening's affair to a close.

Other activities for men included sightseeing and several splendid inspection trips, the most popular one being the trip to the new Ruskin hydroelectric plant of the British Columbia Power Corporation. The annual golf tournament drew 54 registrants from among the golfers and the near-golfers. With the play at the Shaughnessy Heights Golf Club the aspirants were treated to a course not especially sporty, but replete with long holes and strategically located traps in great profusion. The Fisken Cup, prized Pacific Coast trophy named for John B. Fisken of Spokane, Wash., was won by J. E. Underhill (A'29) of Vancouver, B. C., score: 98 − 30 = 68 net. Mr. Underhill stated that he was as astonished as were his competitors; he never before had broken 100. Other winners were: Prof. E. G. Cullwick (A'26), G. K. Haspal (M'31), J. A. Tames (A'27), and S. Anderson of Vancouver; G. I. Wright (M'28) of Philadelphia, Pa., low gross (88); C. R. Higson (M'32) and Prof. J. H. Hamilton (A'28) of

Mercury Arc Rectifier Substation of Pleasing Design



TWO additional mercury arc rectifiers, each of 1,500-kw. capacity, have been placed in service by the Los Angeles Railway Corporation in its new Slauson substation. The rectifiers are provided with complete automatic control. Both the exterior and interior designs of this substation are deserving of attention. Architectural features to harmonize well with other buildings in a residential district are incorporated in the building. One continuous switchboard provides the control for the 2 General Electric rectifiers, 4 a-c 16,500-volt incoming lines, 4 a-c tie breakers, 4 power transformers each rated 1,500 kva 16,500–935 volts, and 12 d-c feeders each rated 600 volts, 1,200 amp. This control board is particularly interesting in that it provides automatic, supervisory, and manual control—whichever may be desired.

Salt Lake City, Utah; J. J. Little (A'22), Prince Rupert, B. C. (158). Successful in estimating themselves into the kickers hat and lucky in having their names drawn therefrom were Joseph Hellenthal (M'23) of Seattle, Wash., C. F. Norburg (A'28) of Spokane, Wash., and M. Legge of North Vancouver, B. C.

District Meeting at Baltimore Impends

Shortly after this issue of ELECTRICAL ENGINEERING goes to press the Institute's Middle Eastern District meeting will be held in Baltimore, Md., October 10–13, 1932, with headquarters in the Lord Baltimore Hotel. A report of this meeting is scheduled for the November issue, and a summary of the discussions on the Baltimore meeting papers will be presented as soon as they are made available by the discussers. To be considered for publication discussions should be written and mailed to the A.I.E.E., editorial department, 33 West 39th Street, New York, N. Y., on or before October 28, 1932.

The program of the Baltimore District meeting was announced in ELECTRICAL ENGINEERING for September 1932, p. 663–4, and abstracts of all papers then scheduled for presentation at the meeting were also given in the September issue, p. 659–62.

Institute Affairs Discussed at Vancouver Convention

A luncheon of Institute, District, and Section executives, and Student Counselors, was held in the Italian room of the Hotel Vancouver on August 31, 1932, in connection with the Institute's recent Pacific Coast convention at Vancouver, B. C. C. R. Higson (vice-president District 9) acted as chairman of the meeting, and after congratulating the local convention committee on their arrangements for this convention, briefly discussed the 1934 Pacific Coast convention. He called attention to the fact that the board of directors of the Institute had approved the recommendation made during the 1931 convention that the 1933 convention be held at Salt Lake City, Utah. The local members under the leadership of B. C. J. Wheatlake have begun their plans for the convention.

A. W. Copley (vice-president District 8) San Francisco, Calif., stated that the board of directors will decide in January 1933, the location of the 1934 Pacific Coast convention, and moved that this meeting recommend to the directors that the 1934 convention be held under the auspices of the Los Angeles Section. This motion was carried unanimously.

Pres. H. P. Charlesworth offered his congratulations to those responsible for the technical and student sessions and the entertainment features, commenting specifically on the featuring of student activities.

He also said that Dr. Frank B. Jewett (past-president) had reminded him that the German electrical engineers this year are celebrating the sixtieth birthday of Dr. Carl Von Siemens, and had suggested that the convention send a congratulatory cablegram to Doctor Siemens. It was moved, seconded, and unanimously carried that H. H. Henline, acting national secretary, be requested to send this cablegram.

The publication in ELECTRICAL ENGINEERING of papers not published in the Transactions was discussed, and a motion was carried that ELECTRICAL ENGINEERING be requested to publish the paper "Metering of Symmetrical Components" by G. R. Shuck, which the technical program committee had recommended be not published by the Institute.

After further discussion of the value of Student sessions and the recommendation that close cooperation between Student Branches and Sections is highly desirable, the meeting adjourned.

A Power Plant in Central Africa

A MODERN power plant differing considerably from those found in the United States is illustrated above. It is owned by the Ndola Electricity Undertaking, Ndola, Northern Rhodesia, Africa, and is located in the heart of the Northern Rhodesian copper belt. The photograph was supplied by D. W. V. Ellis (M'32), manager and engineer, Ndola Electricity & Water Undertakings.

Nomination of 1933 Institute Officers

Actions specified in the Institute's constitution and bylaws relative to the organization of a national nominating committee are being taken, and the meeting of the national nominating committee for the nomination of officers to be voted upon at the election in the Spring of 1933 will be held between November 15 and December 15, 1932. All suggestions for the consideration of the national nominating committee must be received by the secretary of the committee at Institute headquarters, New York, N. Y., not later than November 15, 1932.

The sections of the constitution and bylaws governing these matters are quoted below:

Constitution

28. There shall be constituted each year a national nominating committee consisting of one representative of each geographical district, elected by its executive committee, and other members chosen by and from the board of directors not exceeding in number the number of geographical districts; all to be selected when and as provided in the bylaws; the national secretary of the Institute shall be the secretary of the national nominating committee, without voting power.

29. The executive committee of each geographical district shall act as a nominating committee of the candidate for election as vice-president of that district, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The national nominating committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The national nominating committee shall name on or before December 15 of each year, one or more candidates for president, national treasurer, and the proper number of directors and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical districts, if received by the national nominating committee when and as provided in the bylaws; otherwise the national nominating committee shall nominate one or more candidates for vice-president(s) from the district(s) concerned.

Bylaws

SEC. 22. During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical district that by November 1 of that year the executive committee of each district must select a member of that district to serve as a member of the national nominating committee and shall, by November 1, notify the secretary of the national nominating committee of the name of the member selected.

During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical district in which there is or will be during the year a vacancy in the office of vice-president, that by November 15 of that year a nomination for a vice-president from that district, made by the

rict executive committee, must be in the hands he secretary of the national nominating comtee.

ween October 1 and November 15 of each year, board of directors shall choose 5 of its members erve on the national nominating committee and ll notify the secretary of that committee of the nes so selected, and shall also notify the 5 nbers selected.

secretary of the national nominating committee ll give the 15 members so selected not less than lays' notice of the first meeting of the committee, ch shall be held not later than December 15. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the national nominating committee must be received by the secretary of the committee by November 15. The nominations as made by the national nominating committee shall be published in the January issue of ELECTRICAL ENGINEERING, or otherwise mailed to the Institute membership during the month of January.

(*Signed*) H. H. HENLINE,
Acting National Secretary

October 1, 1932.

ummarized Review of Some Pacific Coast Convention Discussions

RINCIPAL discussions of the Pacific ast convention papers are summarized ewith. The papers to which these disssions refer were abstracted in ELECICAL ENGINEERING for August 1932, p. 3–6.

Only discussion submitted in writing in cordance with governing A.I.E.E. rules summarized. Complete discussion, toher with all approved papers, will be blished in the TRANSACTIONS.

ADING COMPANY'S PHILADELPHIA SUBURBAN ELECTRIFICATION

A. J. Schoch (Philadelphia, Pa.) dissed this subject and corroborated the ainments brought out in the paper as a ult of electrification. He called atten- n to the simplicity and ease of erection d maintenance of the 2-wire catenary tem which experience has shown results a quality of current collection better n that obtained from the usual comund catenary systems. He referred also the improvements made in the car uipment. Aluminum alloys were used in non-stress carrying members, and by a reful location and arrangement of equipnt underneath the car, the original inllation was not only simplified but the of inspecting and maintaining the uipment was made much easier.

ECTRICAL OPERATION ON THE GREAT NORTHERN RAILWAY

W. F. Coors (Tacoma, Wash.) discussed connection with this subject several ubles encountered on the electrical uipment of the Milwaukee Road which re due to unexpected moisture conditions ecting insulation. One of these troubles curred when under certain weather nditions the depression in the top of the ction motor frame housings for recessing field pole capscrew heads filled with ow. Later when the traction motors rmed up at work, the snow would melt d the resulting water ran through the lt holes into the traction motor cases, ually causing field coil insulation failures. is trouble was prevented by filling the esses with battery sealing compound.

G. H. Walker (Seattle, Wash.) briefly t interestingly outlined the electric sysn of this electrification and the terms for purchasing power which include an increase in the demand charge when 13,000 kw is exceeded. It is of interest to note the method by which this demand is limited. This was accomplished by equipping each locomotive unit with an indicating ammeter visible to the engineman and connected in the circuit to the synchronous motor of the motor generator set. Tests were conducted to determine the demand for various readings on the ammeter for each type of locomotive unit. The results were tabulated and given to the train dispatchers who in turn when dispatching trains assign a load limit to each locomotive unit on the line for any given period of time. This the dispatcher does by giving orders to the engineman not to exceed so many amperes between certain locations or at certain times. This method of power limitation has been used without undue handicap to schedules and it has resulted in a considerable saving in power costs. The discussion was supplemented with data on power consumption and traffic, together with a reproduction of an actual train sheet and load diagram.

Another discussion on this subject by R. T. Strong (Seattle, Wash.) drew attention to the distinction that must be made between the terms "locomotive unit" and "locomotive." The latter term designates one or more locomotive units operating together. Mr. Strong then illustrated the importance of selecting locomotive unit sizes so as to obtain the greatest flexibility combined with maximum standardization. It also was illustrated with data given in the paper and from the history of most railway electrifications that train weights originally specified by the railways rarely have been adherred to. The discusser believes that electrical engineers laying out a new railway electrification should keep this tendency in mind and leave an ample margin in the design for increases in train weight. In connection with the condensation difficulties described in the paper, Mr. Strong explained 2 additional causes contributing to high temperatures in the tunnel. These were the presence of warm springs within the tunnel and the heat thrown off by the chemical action of the setting of newly poured concrete. He believes that difficulties with the locomotives are due entirely to condensation within the cabs, and not to snow or water drawn in from the outside.

CORONA LOSS MEASUREMENTS

In connection with this subject W. S. Peterson (Los Angeles, Calif.) presented and analyzed a theoretical formula modified by empirical correction to fill the need for some method of calculating corona loss for the lower values of losses as well as the higher values. In the development of the formula the corona loss was considered to be that due to charging current flowing radially through the corona envelope. The drop in voltage through the envelope was assumed as being the integral of the potential gradient from the point where the gradient in air exceeded 53.6 kv per in. effective values, to a point on the conductor at some higher value. Instantaneous values of current and voltage were used, and for the portions of the cycle at which the voltage is too low to cause air breakdown, no loss was assumed to occur. The discusser explained that the formula evolved from this theory and further empirical corrections had served quite well to give accurate curves for practical engineering purposes. Excellent agreement also has been obtained with a great variety of tests.

TRIPLE HARMONIC EQUIVALENT CIRCUIT IN 3-PHASE POWER TRANSFORMER BANKS

P. W. Blye (New York, N. Y.) in discussion of this subject cited his experience with tests on transformers similar to those made by the authors. These tests corroborated their general conclusion that at a given excitation or over a narrow range of excitation, the equivalent T network described in the paper presents a simple and accurate method of dealing with triple harmonics arising in 2-winding transformers. However, the discusser did not agree with several points brought out in the paper incidental to the general conclusions. For example, the statement in the paper that the total leakage impedance as measured by the usual short-circuit method was found to be considerably in error as compared to the sum of the individual leakage impedances used in the equivalent circuit and observed at normal excitation by the delta-opened-delta method. He also recalled certain cases where the leakage impedance associated with one winding of a 2-winding transformer actually had been found to increase slightly with increasing excitation.

A. Boyajian (Pittsfield, Mass.) in his discussion of this subject referred to the application of a single equivalent circuit for bank No. 3 in Fig. 6 of the paper. He explained that this circuit was not applicable both for the currents produced by E_3 and for those produced by E_2. He believed that a single equivalent circuit to satisfy these conditions would have to be of the 6-link type which is very difficult to construct and use. It was felt that the good results claimed by the authors with the use of a single 3-link equivalent circuit seemed to imply that in the case under consideration the 2 equivalent circuits did not happen to differ materially from one another.

Another discussion by H. V. Carpenter (Pullman, Wash.) considered the magnetic conditions existing during the tests; it was explained that if 3 single-phase transformers were used, each phase would have its own independent magnetic core; if one type of

3-phase transformer were used, the 3 flux paths would be partially but not wholly independent; while if the other type were used, any flux passing through one core must return through the other 2. In this latter case the third harmonic flux would find no return path; so it would seem likely that the 3 different conditions would give somewhat different results.

D. I. Cone (San Francisco, Cal.) discussed this subject and it is his belief that despite the number of published articles, there still is need for the presentation of methods for quantitative prediction of the behavior of given networks. He believed this paper is a helpful contribution toward filling that need. In reference to Fig. 16 he felt that it was most encouraging to observe that even at the resonance point, it was practicable to predict the approximate magnitude of the third harmonic current. In conclusion, he suggested as a desirable extension of this study, others that would concern the distribution of triple harmonics in 3-winding transformers and associated lines.

E. G. Cullwick (Vancouver, B. C.) in his discussion of this paper questioned the authors' statement that the harmonics in the exciting current of a transformer are produced by voltages of like frequency produced in the transformer itself, due to the action of the steel core. He explained that due to the varying reluctance of the iron core, the magnetizing current necessary to produce the flux would not be sinusoidal, but would contain strong third and higher odd harmonics. To represent these harmonics in an equivalent circuit, it is logical to replace the varying impedance of the transformer by a constant impedance and a generator of odd harmonics, but the discusser did not believe it was accurate to state that the harmonics were actually due to electromotive forces generated in the transformer windings.

Segregation of Hydroelectric Power Costs

J. S. Moulton (San Francisco, Cal.) discussed this subject in regard to the conclusions in the paper that assuming that a plant could be constructed to operate at 100 per cent load factor, the base cost per kilowatthour would be the energy cost of service, and that the additional cost incurred by reason of less than 100 per cent load factor operation would be the demand cost of service. The discusser felt that the first of these conclusions was in reality a premise upon which the validity of much of the balance of the paper depended. He pointed out that it is equally correct to assume that the costs involved can be expressed upon a per kilowatt basis. The desirability of considering base costs as demand costs of service rather than an energy cost of service is illustrated by Fig. 7 of the paper and shows that with a fixed generating capacity installed, if the average kilowatts fall below 100 per cent load factor, the cost per kilowatthour increases. From a rate making standpoint, if the output of such a plant is sold upon a kilowatthour basis and upon the assumption that the plant will operate at 100 per cent load factor, and conditions change so that it operates at less than this load factor, it is obvious that at the fixed price per kilowatthour the total plant costs will not be met. On the other hand if the capacity is sold upon a kilowatt basis, then the total plant costs will continue to be met regardless of how the load factor may vary.

Factory Assemblies for Substation Design

J. S. Moulton (San Francisco, Cal.) discussed this subject also and reported that the average life of transmission switchboards in place on a certain system was 14.4 years. The average life for distribution switchboards was 13.2 years. The transmission switchboard account included high voltage oil circuit breakers, disconnecting switches, switch structures and miscellaneous appurtenant equipment. The distribution account included oil circuit breakers of an operating voltage of 11 kv or below, and otherwise was similar to the transmission account. As most of the equipment was relocated and some of it was moved several times during its life, the discusser suggested that serious study should be given to ways of increasing the capacity of existing apparatus so as to eliminate relocation if not abandonment. Study also should be given to ways of reducing the amount of installation labor, which must be written off in the case of a change in location.

Section Activities for Fiscal Year Summarized

As part of an effort to distribute as widely as possible the benefits of affiliation with the Institute, a plan was formulated in 1902 to organize local groups of Institute members in electrical centers. Since that time the activities of these Sections have expanded very rapidly, and with the formation of a Montana Section authorized by the Institute's board of directors on June 24, 1931, the number of Sections was brought up to 60. Approximately 80 per cent of all Institute members now are within Section territory.

Section activities for the fiscal year ending April 30, 1932, were normal, and programs included a wide variety of interesting and important subjects. Despite the unfavorable business conditions, the number of applications for admission received from Section territories during the fiscal year was more than 94 per cent of the corresponding number for the preceding fiscal year (1,209 and 1,280, respectively). Many of the Sections have appointed committees to study the qualifications of their members and to urge those who are fully qualified for a higher grade to submit their applications for transfer.

Arrangements made in recent years involving interesting developments in activities were continued in effect. Notable among these are: the 2 joint meetings of the Pittsfield and Schenectady Sections each year for the presentation of papers by younger members in competition for prizes; the practise of Sections to have programs supplied largely by their members; the effective public speaking instruction spon-

Table I—Section Meetings Held During Yea[r] Ending April 30, 1932

Section	A.I.E.E. Members Aug. 1930	A.I.E.E. Members Aug. 1931	Meetings During Year No.	Meetings During Year Avg. Attendance	Avg. Attendance as Per Cent of Membership Aug. 1931
Akron	79	75	7	274	365
Atlanta	111	102	6	223	218
Baltimore	191	217	8	274	126
Birmingham	52	38			
Boston	535	513	8	598	117
Chicago	1,117	1,098	4	332	30
Power Group			6	134	
Cincinnati	169	168	11	132	78
Cleveland	290	274	10	789	288
Columbus	71	62	9	432	696
Connecticut	271	263	6	112	43
Dallas	122	114	9	91	80
Denver	156	154	11	66	43
Detroit-Ann Arbor	336	310	10	211	68
Erie	98	99	8	110	111
Florida		42	3	37	88
Fort Wayne	76	80	6	69	86
Houston	75	71	9	51	72
Indianapolis-Laf	88	88	8	126	143
Iowa	59	62	5	47	76
Ithaca	40	38	4	62	163
Kansas City	146	158	10	241	153
Lehigh Valley	287	271	7	141	52
Los Angeles	447	477	9	144	30
Louisville	49	53	10	150	283
Lynn	130	134	15	558	417
Madison	56	55	6	52	94
Memphis	37	53	12	40	75
Mexico	91	94	8	45	48
Milwaukee	227	221	10	203	92
Minnesota	95	96	7	771	803
Montana*		26	4	47	181
Nebraska		55	2	130	236
New York	3,865	3,794	4	831	22
Communication Group			3	367	
Illumination Group			3	208	
Power Group			4	331	
Transportation Group			3	367	
Niagara Frontier	155	176	11	88	50
North Carolina	77	83	2	148	178
Oklahoma City	46	64	11	197	308
Philadelphia	795	760	8	127	17
Pittsburgh	790	724	9	268	37
Pittsfield	147	137	11	677	494
Portland	132	121	11	76	63
Providence	78	80	5	110	137
Rochester	108	103	9	182	176
St. Louis	246	256	8	317	124
San Antonio	66	65	8	57	88
San Francisco	484	460	9	162	35
Saskatchewan	33	39	3	35	90
Schenectady	485	456	11	207	45
Seattle	228	218	10	93	43
Sharon	114	111	9	173	156
Southern Virginia	91	85	3	55	65
Spokane	47	46	9	42	91
Springfield, Mass	91	99	9	460	464
Syracuse	67	68	3	205	301
Toledo	72	87	13	272	312
Toronto	398	388	16	137	35
Urbana	37	36	7	85	236
Utah	62	58	9	46	79
Vancouver	90	91	12	50	55
Washington	176	183	7	92	50
Worcester	61	61	9	146	239
Total 60	14,596	14,410			

Total number of meetings........ 497
Total attendance................105,325
*Organized September 12, 1931.

sored by the New York Section; specia[l] joint meetings with students in severa[l] Sections; the lecture courses sponsored b[y] the Chicago Section; and local prize com[-] petitions held by many Sections. Th[e]

eveland Section distributed with the tice of its December meeting a questionire designed to learn in considerable tail the wishes of its members with respect the types of meetings to be held in the ture. The suggestions received are excted to be of material aid in the planning meetings for this coming year.

The group (power, transportation, comnication, illumination) activities of the icago and New York Sections were ntinued with excellent results. The icago Section and other local engineering ganizations continued the arrangements post-college education of engineers begun in 1929. A review of these tivities was published on p. 280–1 of the ril 1932 issue of ELECTRICAL ENGINEER-G.

Resolutions were adopted by the board directors October 23, 1931, urging the ctions to consider organizing engineers' employment relief committees in coopera-n with other engineering groups. A large mber of the Sections participated in the rmulation and execution of plans directed ward making work and furnishing finanl assistance to engineers in need for whom sitions could not be secured. A review these efforts and their results is contemted for an early issue of ELECTRICAL IGINEERING.

In the fifth annual report on Section and anch activities covering the fiscal year ding April 30, 1932, considerable informan concerning meetings is given. This ormation is presented herewith in Tables nd II.

ble II—Section Meetings Held During Last 3 Fiscal Years

	Fiscal Year Ending April 30		
	1930	1931	1932
mber of Sections	56	59	60
mber of meetings held	480	491	497
erage number f meetings	8.6	8.3	8.3
tal attendance	84,727	108,523	105,325
g. attendance er meeting	177	221	212

ranch Activities for Fiscal Year Summarized

The interest in the Student Branch tivities which has been so marked for the t 2 or 3 years is still as alive as ever, as denced by the number of meetings held l the large number of student papers ivered. There is no doubt that this m of activity of the Student Branches, continued, is destined to produce eleccal engineers who can write good techal papers and present them clearly and ectively.

The committee on Student Branches, addition to giving electrical engineering dents training in the activities of the titute while they are still in college, been working for the past year on the problem of improving the grade of the student who applies for courses in electrical engineering in the educational institutions. For the purpose of encouraging those who should go into electrical engineering, and to discourage those who are unfitted for such a career, the committee prepared a 32-page booklet. Following a preliminary distribution of this booklet, requests for about 9,000 additional copies were received.

Table I—Branch Meetings Held During Year Ending April 30, 1932

Branch	Meetings During Year: Number	Meetings During Year: Avg. Attendance	Approx. No. of Talks by Students
Akron, University of	8	12	11
Alabama Polytechnic Inst	13	18	7
Alabama, University of	9	161	3
Arizona, University of	28	8	17
Arkansas, University of	15	29	39
Armour Institute of Tech	12	50	
British Columbia, Univ. of	12	24	17
Brooklyn, Poly. Inst. of	8	53	11
Bucknell University	10	18	6
California Institute of Tech	6	49	
California, University of	15	40	9
Carnegie Institute of Tech	4	38	2
Case School of Applied Science	7	56	6
Catholic Univ. of America	6	36	1
Cincinnati, University of	6	39	
Clarkson Col. of Technology	9	36	6
Clemson Agricultural College	12	34	27
Colorado State Agr. Col	6	19	1
Colorado, University of	15	50	8
Cooper Union	3	49	
Cornell University	4	42	
Denver, University of	18	29	3
Detroit, University of	8	55	2
Drexel Institute	9	21	6
Duke University	8	17	15
Florida, University of	12	52	6
Georgia School of Technology	7	74	
Harvard University	8	71	4
Idaho, University of	5	32	3
Illinois, University of	16	65	6
Iowa State College	8	127	4
Iowa, State University of	22	56	25
Kansas State College	18	52	10
Kansas, University of	11	57	9
Kentucky, University of	8	40	5
Lafayette College	9	38	8
Lehigh University	5	60	7
Lewis Institute	12	67	4
Louisiana State University	4	20	3
Louisville, University of	9	17	12
Maine, University of	6	20	10
Marquette University	8	50	6
Massachusetts Inst. of Tech	11	91	3
Mich. Col. of Mining & Tech	8	29	5
Michigan State College	12	22	5
Michigan, University of	12	71	1
Milwaukee, School of Engg. of	7	104	8
Minnesota, University of	8	51	4
Mississippi State College	4	28	2
Missouri School of Mines & Met	10	44	13
Missouri, University of	8	92	7
Montana State College	25	110	99
Nebraska, University of	11	45	6
Nevada, University of	6	32	
Newark Col. of Engineering	13	50	10
New Hampshire, Univ. of	19	35	21
New Mexico, University of	10	18	6
New York, Col. of the City of	16	38	2
New York University	11	15	17
North Carolina State College	9	31	7
North Carolina, University of	6	36	
North Dakota Agr. College	10	49	13
North Dakota, University of	14	18	10
Northeastern University	4	78	
Notre Dame, University of	14	200	26
Ohio Northern University	8	31	3
Ohio State University	8	36	
Ohio University	8	34	4
Oklahoma A. & M. College	13	28	17
Oklahoma, University of	9	31	4
Oregon State College	8	49	5
Pennsylvania State College	9	60	17
Pennsylvania, University of			
Pittsburgh, University of	32	115	28
Pratt Institute	14	38	11
Princeton University	4	9	3
Purdue University	7	161	2
Rensselaer Polytechnic Inst	6	127	7
Rhode Island State College	18	19	20
Rice Institute	16	24	12
Rose Polytechnic Institute	8	43	6
Rutgers University	6	18	5
Santa Clara, University of	10	85	2
South Carolina, University of	22	36	27
So. Dakota State School of Mines	9	35	2
South Dakota, University of	2	23	
Southern California, Univ. of	24	28	
Southern Methodist Univ	10	31	3
Stanford University	11	29	5
Stevens Institute of Tech	11	42	2
Swarthmore College	1	85	1
Syracuse University	24	31	37
Tennessee, University of	11	71	4
Texas, A. & M. College of	10	128	12
Texas Technological College	8	17	10
Texas, University of	9	26	7
Utah, University of	12	41	10
Vermont, University of	11	20	4
Virginia Military Institute	12	67	43
Virginia Polytechnic Inst	18	49	43
Virginia, University of	3	16	5
Washington, State College of	13	35	8
Washington University	6	31	1
Washington, University of	18	28	4
West Virginia University	16	29	90
Wisconsin, University of	7	58	7
Worcester Polytechnic Inst	2	29	1
Wyoming, University of	12	14	10
Yale University	2	30	
Total	109		1,066
Total number of meetings	1,135		
Total attendance		54,197	

Table II—Branch Meetings Held During Last 3 Fiscal Years

	Fiscal Year Ending April 30		
	1930	1931	1932
Number of Branches	106	109	109
Number of meetings held	1,009	1,137	1,135
Average number of meetings	9.5	10.4	10.4
Total attendance	50,401	51,807	54,197
Average attendance per meeting	50	46	48
Number of student talks	844	1,085	1,066

Table III—Summary of Monthly Reports on Branch Activities Appearing in the November to June Issues, Inclusive, of ELECTRICAL ENGINEERING of the Last 5 Academic Years

	1927–28	1928–29	1929–30	1930–31	1931–32
No. of Branches Jan. 1	95	100	104	107	109
Avg. no. of Branches reporting meetings per month	58	56	60	67	68
Avg. no. of Branches reporting student talks per month	24	30	35	39	36
Total no. of meetings	807	806	891	957	956
Total no. of student talks	646	767	893	966	919

Table IV—Comparison of Branch Activities by Districts

District	No. of Branches Jan. 1	Avg. No. Meetings per Branch	Avg. Attendance per Meeting	Approx. Avg. No. Student Talks per Branches	No. of Branches Reporting 8 or More Student Talks
1	13	9.5	42.5	8.7	4
2	18	8.3	51.3	10.7	5
3	8	10.3	37.8	7.3	4
4	17	9.8	47.0	12.3	6
5	16	10.5	75.0	6.9	3
6	9	10.7	32.5	5.9	4
7	14	10.9	42.0	10.7	8
8	7	14.3	31.5	4.7	2
9	6	13.5	58.1	21.5	3
10	1	11.0	24.3	17.0	1

Table V—Conferences on Student Activities

District	Location	Date
1	Rochester, N. Y. (North Eastern Dist. Mtg.)	5/ 1/31
8 & 9	Lake Tahoe, Calif. (Pacific Coast Conv.)	8/27/31
7	Kansas City, Mo. (South West Dist. Mtg.)	10/23/31
4	Gainesville, Fla.	12/ 4/31
2	Haverford College, Pa.	3/14/32
5	Milwaukee, Wis. (Great Lakes Dist. Mtg.)	3/14/32
6	University of Denver	4/15–16/32

The committee on Student Branches also has contributed the chapter on electrical engineering for the pamphlet being prepared by The Engineering Foundation to contain information on the main divisions of engineering.

In Tables I to VI, inclusive, is given information which was presented in the annual report on Section and Branch activities, covering the fiscal year ended April 30, 1932.

Table VI—Student Conventions

Sponsored by District	Location	Date	No. of Student Papers
1	Rochester, N. Y. (North Eastern Dist. Mtg.)	5/1/31	8
8 & 9	Lake Tahoe, Calif. (Pacific Coast Conv.)	8/26/31	12
7	Kansas City, Mo. (South West Dist. Mtg.)	10/23/31	10
4	Gainesville, Fla.	12/4/31	....
Phila. and Lehigh Valley Sections	Haverford College	3/14/32	4
5	Milwaukee, Wis. (Great Lakes Dist. Mtg.)	3/14/32	10
3 (and New York Section)	New York	4/29/32	3

Pearl Street Station Opened 50 Years Ago

September 4, 1932, marked the 50th anniversary of Thomas A. Edison's first permanent commercial incandescent lighting system. This first Edison system was the Pearl Street station and district in lower New York City.

The anniversary was celebrated by 2 events. The first, on September 4, was held at the site of the old station, 255–7 Pearl Street, at which many Edison veterans and men of prominence in the electric light and power industry were present. The second observance took the form of a dinner held on September 12, and was attended by representatives of the electrical industry and civic, scientific, and engineering bodies.

At its opening on September 4, 1882, the Pearl Street station served an area of about 1 sq mile in lower Manhattan, distribution being by about 15 miles of underground cable. The capacity of the station was approximately 750 hp, and supplied electric light to 59 customers.

Trade Acceptances Urged for Financing.—A concerted plan has been initiated by leading American industrialists to stimulate interest in the use of trade acceptances as a means for the expansion of the volume of credit available to industry. The use of trade acceptances has the effect of speeding up the turnover, increasing the net return, and improving the credit standing of business concerns, since collections would be expedited by the substitution of readily negotiable paper for slow open-book accounts. The trade acceptance method should be restricted to current transactions for purchases and sales of goods, and should not be extended to past due accounts. In order to give definite information concerning the trade acceptance method and to assist in determining the advisability of adopting this system in any particular business, circulars have been sent out by the National Industrial Conference Board, Inc., New York, N. Y., in which it has endeavored to set forth briefly the operations of the plan and the advantages to American industry which would result from its use.

Section and Branch Joint Meetings Continue Successful

The cooperative relations between Institute Sections and neighboring Student Branches of the Institute have continued to receive much attention during the past year. The excellent methods developed for maintaining close contacts between Sections and Branches were continued, and the results are becoming increasingly apparent as more and more of the students who have participated in them subsequently have become active Section members.

Some of the principal cases of such cooperation during the past fiscal year and which resulted in obvious benefit both to members of the Sections and Branches, are given in the annual report on Section and Branch activities, covering the fiscal year ending April 30, 1932. This information is presented herewith in Tables I and II.

Table I—Section or Joint Section and Branch Meetings With Active Student Participation

Sections	Schools	Date	Student Talks	Attendance
No. Carolina	Univ. of No. Carolina	11/10/31	1	115
Portland	Oregon State College	12/ 8/31		74
Pittsburgh	Univ. of Pittsburgh Carnegie Inst. of Tech. Univ. of W. Virginia	1/12/32	6	340
Los Angeles	Calif. Inst. of Tech. Univ. of Southern Calif.	3/ 8/32	5	106
Cleveland	Case School of App. Sci.	3/24/32	2	180
Spokane	Univ. of Idaho Wash. State College	3/25/32	2	65
Utah	Univ. of Utah	3/30/32		45
Urbana	Univ. of Illinois Purdue Univ. Rose Poly. Inst.	4/ 2/32		166
Columbus	Ohio State Univ.	4/22/32		44
Total		9	16	1,135

Table II—Section or Joint Section and Branch Meetings With Student Programs

Section	Schools	Date	Student Talks	Attendance
Cincinnati	Univ. of Cincinnati	5/14/31	6	80
Oklahoma City	Univ. of Okla., Okla. A.&M. Coll.	5/18/31	8	115
Utah	Univ. of Utah	5/18/31	4	20
Portland	Oregon State College	5/23/31	4	100
Kansas City	Univ. of Kansas	11/ 5/31	2	200
Madison	Univ. of Wisconsin	12/10/31	3	53
Urbana	Univ. of Illinois	1/ 6/32	4	31
Dallas	Southern Methodist Univ.	1/18/32	3	60
Vancouver	Univ. of British Columbia	3/ 7/32	3	47
Louisville	Univ. of Louisville	3/18/32	5	66
San Francisco	Univ. of Calif., Stanford Univ., Univ. of Santa Clara	4/15/32	3	128
Bucknell Univ.	Penn. State College	4/27/32	2	49
Denver	Univ. of Colo., Univ. of Denver, Colo. Agri. Col., *Colo. School of Mines, Univ. of Wyoming	4/29/32	4	65
Total		13	51	1,014

* No Branch.

oodlighting Aids in Pushing Construction

ONE construction project of sufficient urgency to require 24-hr per day activity was
e building of a 13,000,000-bushel grain elevator at the Port of Albany, N. Y. Night
erations were facilitated by a floodlighting installation consisting of 2 wooden towers
ft high supporting 6 1,000-watt General Electric floodlights at each of 2 locations;
ese units were supplemented by 3 units located on the roof of a concrete mixing structure,
king a total of 15 kw for the complete installation.

nnual Economic Conference Held

The second annual economic conference
engineers was held at the engineering
np of the Stevens Institute of Tech-
logy, near Johnsonburg, N. J., August 27
September 5, 1932. Attendance this
ır was particularly gratifying, and was
tinguished by the presence of a number
individuals prominent in engineering and
nomic activities, as well as many others
erested in acquiring a knowledge of the
ader economic aspects of present day
. Perhaps the most important thing
out the conference was the fact that it
denced a considerable desire on the part
engineers to assist in understanding and
ving the large scale problems of political
nomics, the creation of which problems
gineering accomplishments are held at
st partially responsible.

The morning lectures continued through-
the 10 days of the conference, and were
rided into 2 sessions. One on the subject
'Money" was conducted by Prof. W. D.
nis, head of the department of economics
engineering at Stevens Institute of Tech-
ogy, and the other on the subject of
anking" was conducted by A. V. Shaw,
estment counsel, of New York, N. Y.
e afternoons were left free for any activi-
desired, which included swimming in
spring-fed lake at the camp, and golf
tennis at other points in the vicinity.
enings were devoted to a series of con-
ences on various subjects, each under the
dership of an authority in his particular
d.

n addition to analyzing the existing eco-
nic system, definite suggestions were
de at these conferences for remedying
and assisting in the stabilization of
ces and industrial activity. These sug-
tions might be grouped roughly into 2 classes, one of which is the modification of the existing system by measures under government control and for the purpose largely of regulating credit, and the other contemplating more radical alterations in the system. It is felt that those present at these conferences obtained a clearer idea of the more or less mysterious forces underlying economic changes, and were left with a definite desire to be of assistance in the solution of economic problems.

Southern California Power Official Dies

Russell H. Ballard, president of the Southern California Edison Company, Ltd., died of pneumonia at his home in Los Angeles, Calif., August 24, 1932. Mr. Ballard was born in Hamilton, Ontario, Canada, July 26, 1875, and came to the United States in 1883, working as an office boy in the Thomson, Houston Electric Company in Chicago, Ill. He was with the treasury department of the General Electric Company, Schenectady, N. Y., from 1890 to 1893, and was placed in charge of collections and credits for this company in the southern states, with headquarters at Atlanta, Ga., in 1896.

Except for about 4 years between 1900 and 1904, Mr. Ballard has lived in Los Angeles since 1897, serving the Southern California Edison Company, Ltd., and its predecessors. Starting first as bookkeeper and later becoming auditor, Mr. Ballard progressed steadily through the company's organization, being appointed vice-president and general manager in 1924, and president in March 1928. His organizing and operating genius was recognized throughout the industry.

He was a past-president of the National Electric Light Association and the Pacific Coast Electrical Association, and held membership in the Franklin Institute of Philadelphia, Pa. He has been the recipient of many honors and was the first to receive the John B. Miller Medal for distinguished service to his own company. In recent years Mr. Ballard has been identified prominently with community work in Los Angeles.

G. C. Ward (M'24) its senior vice-president will direct the Edison company's activities "with the advice and counsel of the enlarged executive committee" according to an official announcement recently made which stated that any adjustment in the management that may become necessary by reason of Mr. Ballard's death will be deferred.

"5-Watt" Lamps Which Average 12 Watts

Incandescent lamps may and do vary with respect to light output and efficiency—qualities not designated on the lamp. The public, however, should be able to rely upon the substantial correctness of the watts designation which does appear on the lamp.

Recently Japanese lamps have been found upon the American market bearing "5-watt" designations. Electrical Testing Laboratories, Inc., New York, N. Y., on behalf of member companies of the Association of Edison Illumination Companies, having surveyed these products, find that such lamps are anything but 5 watts, averaging about 12 watts (as shown in Table I) and ranging as high as 20 watts. Such misleading marking of incandescent lamps is inexcusable, these laboratories contend.

Table I—Measurements of Wattage of Japanese Lamps, Rated at 5 Watts, Purchased in Various Cities

City	Number Measured	Average Watts
Detroit	23	11.2
Warren	10	10.6
Boston	53	11.1
Philadelphia	24	11.8
Waterbury	11	11.9
New York	39	11.7
Chicago	13	13.9
Butte	2	11.1
St. Louis	37	12.5
Youngstown	2	13.4
Total	214	11.8

—From an article appearing in *Electrical World* for August 20, 1932, p. 253.

A New Series of Magnet Steels.—The perfection of a new series of magnet steels by Dr. T. Mishima, an assistant professor at the Tokyo Imperial University of Tokyo, Japan, is announced in the July 1932 issue of *Ohm*, a Japanese magazine devoted to electrical engineering. A translation of the original announcement prepared by J. A. Rabbitt and Dr. T. Fujiwara of the Japan

Nickel Information Bureau, Tokyo, states that these new magnet steels are called by the inventor "MK" steel and are characterized by a very high order of permanence. The announcement says that the coercive force is claimed to be about 9 times that of the usual tungsten magnet steels and $2^1/_2$ times that of the best cobalt magnet steels. The residual magnetism can be varied so that its value is between that of tungsten and cobalt magnet steels. The MK steels consist mainly of iron, nickel, and aluminum. A typical composition is 25 per cent nickel, 10 per cent aluminum, and the balance iron, but the nickel may be varied from 10 to 40 per cent and the aluminum from 1 to 20 per cent. The MK steels are not readily forged and therefore must be cast into the desired form. However, their desirable magnetic properties are developed by simple annealing and they are therefore free from the difficulties of quenching which is required with the tungsten steels. In addition, the announcement says that the magnetic properties of the MK steels do not change appreciably with increase in temperature even to the extent of several hundred deg C. They are said also to be magnetically stable when subjected to mechanical vibration or shocks.

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely.

STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

Has Man Benefited by Engineering Progress?

To the Editor:

From the articles printed in ELECTRICAL ENGINEERING on the question, "Has Man Benefited by Engineering Progress?" and the letters of comment they have elicited, it is plain we engineers feel moved to a certain searching of our hearts to determine whether we are living up to what we conceive to be our proper position in the community; and with this there goes also a disposition to inquire whether, on the part of the community, there is a readiness to accord us all the recognition to which we feel entitled. It is our belief, more or less definitely formulated, that most public questions are, in their essence, engineering problems, whose solutions should be sought, therefore, by the methods of our profession; and we tend to receive with some impatience what we regard as the snap judgments on these of politicians, financiers, and real estate operators, judgments that appear to us to be derived rather from the inner consciousness of the presenter than from that careful collection of data and that correct treatment of them to which we are used. We are accustomed to think, and now and then to say, that the competence to pass on these questions lies really with us, rather than with any of the other professions or callings; and we are wondering whether, if this be not generally admitted, the fault lies with the other professions, possibly jealous of us, or with the community at large, apparently oblivious to us, or with ourselves, for hiding our light under a bushel. We are asking ourselves, now, what, if anything, we may, can, or must do to set these things right.

It is being said among us, we must emerge from any seclusion where we may have been keeping ourselves, we must assume a leading part in civic and national affairs. . . . The picture is painted of our profession as the center from which shall emanate influences to guide our cities, our country, toward ideals of spaciousness and beauty, and of our publications as the inspiration and comfort of all that are fighting the good fight against ignorance, indifference, or turpitude. . . . This, briefly, is the picture some of us see in our minds' eyes; what is wrong with it?

Perhaps nothing, but, at any rate, it will be wise to look over the field more in detail, before deciding to enter the competition. For it is a competition. So far are our public problems from going a begging for solution that the want for an answer to any question of social policy is as uncommon as Byron found that for heroes to be, "When every year and month send forth a new one." . . . We wonder, and, as has been hinted, we envy; and we ask, if a physician or a jurist can do these things, why may not an engineer do them better? Ah, why? It will not be safe to leave that question behind us unanswered.

There is a welcome emancipation for the mind in considering unfamiliar things. About these, untrammelled by stubborn facts, the fancy may play; since we do not know the truth about them, we may paint them to suit us; if we do not confess our ignorance, and speak oracularly, we may succeed in having our utterances accepted at their face value. We may even attain to believing them ourselves, and thus may our dreams be in a fair way to come true. So it happens that, if a silk stocking manufacturer has visited London or Paris recently, and is asked what, from his observation while abroad, he would offer as a relief for the congestion in Philadelphia's streets, he does not hesitate to give a comprehensive answer. . . . But, is this what we are yearning to emulate?

Certainly not! We know that easier way is not for us. It is not that we assume any unhuman superiority; we were men before we were engineers. We will bet on a horse with any justice of the supreme court; we are as ready as the next man to tell a friend how to cure his cold; but if you ask us what is the correct ratio of the height of a building on Chestnut Street, between 10th and 11th, to the width of that street, we will say we do not know; and we stir uneasily, if we hear a clergyman answering that question offhand. The trouble is, these questions, as we recognized at the outset, are engineering questions, and we are estopped from answering them as do those in other walks of life. Those others at whose ready-made pronouncements we have been smiling, are just as chary as we of resolving doubts within the provinces of their professions; the physician does not diagnose the disease without seeing the patient, nor the lawyer take the case without knowing all the evidence. These engineering problems are ours to solve, and ours only, but we must solve them in our way and that way is by the collection and study of data. The engineering profession cannot undertake, in the blithe, light-hearted way of those we have been belittling, to take the lead in these public projects.

Must we, then, redraw our picture, and shape it farther from our heart's desire? Let us look over the field again. How fare these competitors of ours in the long run; do they finish the race? Seldom, if ever; we are justified in our reluctance to take them seriously. Their dreams, lacking both inspiration and perspiration, prove evanescent. Our rulers, the professional politicians, regard them with the tolerant contempt the professional has always for the amateur; that is the measure of their futility. If then, we might enter the field in our own way, handling technical questions as technicians, we should encounter no opposition. Is that a practicable course?

It would hardly seem so, for the conclusive reason that we are not given, and cannot take, the opportunity for the collection of the essential data on most of these questions. . . we can easily see they often involve such sciences as psychology, economics, and sociology, all sciences that have great difficulty with the question, "How much?" when asked of their subject matter. Such sciences give the engineer nothing to take hold of. There may be such a technique as human engineering, or social engineering; and all engineers must include economic factors in their problems; but how far we are from effectually applying such sciences, in the true engineering sense, is quite clear from a reading of the series of articles that instigated this inquiry. Quite as able they are as anything from the bankers, the captains of industry, the statesmen, the educators; but it seems they should be taken as a salve, rather than as an excitant, for our itch to get our hands on the wheel of the ship of state. We are not yet ready, no readier than those we condemn.

Obviously then, a course of preparation is indicated. Just what form that should take is the first question to which we should address ourselves. A central bureau for the collection of data seems the first requisite. A closer union among all our national engineering organizations is another. It is the voice of the engineers of America, and not that of the electrical engineers alone, that should be heard on national questions. An ample headquarters and close communication with our outposts, we already have. Let us now bend our energies toward perfecting the preparation we need, deferring, until that is in operation, all further complaints of not being permitted the opportunities we feel we can seize when we are prepared.

Very truly yours,

RUDOLPH H. KLAUDER (A'97)
(7447 Devon St., Mt. Airy, Philadelphia, Pa.)

To the Editor:

A word of caution should be raised in the discussion about the mechanization of man's activities and about the assured deleterious influence of the increasing tendency of mankind to remain indoors.

he chocolate-brown skin of the beach itue is a striking example of what the ıan body will do in order to protect itself ı an overdose of the sun's radiation. anin is laid down in the skin to lessen penetration of the light. Perfect health be had with an infinitesimal amount of solar radiation which an individual who s out-of-doors absorbs.

he effect of drugs, of exposure to light, of other stimuli follow well-known siological laws which have more or less logarithmic character because of which ttle goes a long way. Fish live out of ge of the therapeutic effect of the sun's s, and birds and the beasts of the forest field are covered with scales, feathers, , wool and what not that most effectively the sun's rays away from nearly all heir skin. So it is evident that the skin l not be exposed to very much light.

modern residence, be it a palace overcrowded tenement house, possesses ıy and distinct advantages over the cool, ıp, sweaty-walled cave without, for nple, any semblance of toilet facilities.

ur getting into clothes has been gradual. ıdreds of generations of Caucasians, at t, have passed into and out of this earth e we first began to dress. Yet it would n that the population of the earth is ıter now than in any previous era. s is a pretty good indication that our sent mode of life is as healthful as it ever been.

he medical examinations of candidates military service during the World War wed a greater percentage of physical cts among those from the rural districts ı among those from the urban popula- in spite of the fact that the former were ling an outdoor life.

hese conditions are greatly at variance ı Bachem's quotation from Pearl, "Mor- ty is distinctly lower for outdoor than indoor workers. This indicates the erior healthfulness of outdoor life." twelfth article of Engineering Founda- 's symposium "Has Man Benefited by gineering Progress?" in ELECTRICAL GINEERING for August 1932, p. 553–5.) is a typical illustration of how bio- rical data and observation can be inter- ted to illustrate a particular tenet. ose who work outdoors invariably have e diversified tasks to perform and re- e a greater all-round exercise of mind and scular coordination and, undoubtedly, for important reason are also more inclined e healthy.

he machine has been mankind's greatest n and has given an unparalleled impetus civilization. The great problem, with enormous saving of time and effort thus cted, is not to urge mankind to seek sure on the picnic grounds or in the lic amusement halls where paid per- ners entertain but to urge it to use gain- the surplus energy which it now has a result of mechanization. The mere ing of pleasure and taking of recreation e a less beneficial permanent trace of satisfaction afforded than do more thwhile things.

people who are imbued with the spirit mbition and are willing to sacrifice for cation and advancement in the arts and ıces and even in commerce and industry profit through a raising of the general l of desire above the base spirit of sure seeking, which, at least in part, prevails. Very wisely the founders ur country put the pursuit of happiness r life and liberty, thereby, tacitly per- s, recognizing that its consideration ıld not come first.

here should be fewer pool rooms and ion picture theatres and more schools, rches, and privately owned homes. Pleasure seeking in itself is invariably not so conducive to true happiness as is creative achievement.

Very truly yours,
ROY KEGERREIS, M.D.
(A'14 and Life Member)
(311 N. Oak Park Ave., Oak Park, Ill.)

Engineering Subjects in the College Program

To the Editor:

The measure of success achieved by the technical schools in training students depends largely upon the ability of the directors to keep up with the changes in business and to anticipate the trends of the future. It is more vital today than ever before that the graduate should be prepared to meet the rapidly changing conditions and requirements of business. A liberal margin of security, favored by natural isolation, aided business during the period through which we have just passed, to the extent that rigid economy and a high degree of efficiency was not necessary. The rapid advances made in transportation and communication facilities have limited the isolation previously enjoyed, and in turn raised the standards of efficiency.

Those changing conditions open a broader field for engineering; the fundamental purpose of which is to achieve maximum efficiency at minimum cost. To accomplish that the engineer must enter the field of management and business control. With the new fields in view the schools must recognize the increasing importance of teaching subjects pertaining to the present day practise of business. Practical business courses should be added wherever it is possible to insert them.

Alfred H. Lovell in his paper on "Engineering Subjects in the College Program" (see ELECTRICAL ENGINEERING for August 1932, p. 568–71) outlines some of the changes that have been made in the curricula of the technical schools to provide a more complete business training. Mr. Lovell points out that many of the schools have omitted foreign languages. Subjects that have been carried along for years by precedence and pride. To eliminate them is a step forward.

The value of shop work has been questioned as it is rarely used in practise today. Standardization has had much to do with eliminating the need for local work. Parts can be secured on short notice from any section of the country, it is no longer a local affair. Although useful, shop work will undoubtedly follow foreign languages and be replaced by subjects more applicable to the work encountered in the field.

There has been a general increase in the number of hours of training given in the department of English, which is very commendable. Report writing is more necessary today than ever before and it should be stressed in that department.

A question has been raised as to the value of surveying. Personally I would defend it as it is by nature a specialized course in mathematics and provides excellent and exacting training. It is also a very practical subject. There are, however, many subjects drafted from older engineering courses that can be replaced by those concerning present day practises. A careful survey of that part of the curricula will help to solve the time problem confronting most schools of engineering and develop a more practical course.

Yours very truly,
ORRIN S. VOGEL (A'29)
(Atlanta, Ga.)

Consumption, Production, Distribution

To the Editor:

The American Engineering Council committee, in its progress report entitled "The Relation of Consumption, Production, Distribution" (see ELECTRICAL ENGINEERING for June 1932, p. 373–7) has attacked an extraordinarily difficult and broadly comprehensive subject and has made a remarkably good presentation of preliminary results obtained within the scope of money and time which have been available to the committee. The results thus far obtained justify the expression of hope that the committee may be given support to continue its studies.

The statement made by the committee of its points of attack is an excellent résumé of 8 important threads. The characteristic of research and adaptation is intermixed with all these threads. In my opinion the committee has not made enough of that—research coming first and adaptation being the process of applying the principles brought out by the results of the research. This application of these principles to daily affairs must be made in 2 ways, one being direct and the other being through education. The education ties back again into means for improving the research and thereby making continuous progress. I agree with the committee that the objective which they have stated is physically possible for the whole of western civilization. To accomplish such realization, however, it becomes necessary to view the world as it is, with the modes of life, as they are, founded upon our present day development of science and invention. We cannot suitably support social practises for the present day by excerpts from and references to the writings of Adam Smith, Hume, Ricardo, John Stuart Mill and their associates covering a period of a century and a half beginning substantially a quarter of a millennium in the past. Over-constant adherence to the tenets of these ancient writers on economics is one of the reasons of inutility which pertains to modern day doctrines of political economy as pronounced by the economists. Political economy must be adapted to the modes of life of the age in which the application is made.

The committee wisely concludes that suitable economic readjustment can be realized to a large degree in the United States even if it is not contemporaneously accomplished throughout the western world. This view has an optimistic tinge, but its soundness is well worth proving and is likely to be proved in the near days. Certain aspects of many of the philosophical arguments that have been broadcast from economists and international bankers during the last 2 years have had an unfortunate influence besides being inaccurate. Iteration of the cry that the joint troubles of the western world must be cured before we can recover from our own financial and industrial difficulties is disturbing as well as false. It is particularly disturbing because it misleads our people into believing that they can do nothing for themselves, but must idle until the international bankers have extricated us. The contrary is the fact and we need exhortation to wring our salvation out of our own environment. The sounder attitude of the American Engineering Council's committee pronouncement is refreshing to observe. We cannot wait for the bankers and economists to clear up the international situation for the mutual good of the world, however active their efforts may be, before we put forth efforts to ameliorate our own individual situation. We must put our shoulder to the wheel of our own cart in the meantime,

while the international efforts proceed. Our own agricultural follies need better attention; our own industrial methods need modification and our industrial products given a character which will enable them to be sold without the application of artificial draft; our public expenditures require pruning, and happily this view has taken strong hold throughout the nation within the last few months; common thrift needs a new recognition as good practise.

The committee expresses 6 aspects of popular explanations of our present difficulties, of which explanations they find each and all to be questionable and/or inadequate. It is my opinion that the committee is right, except partially for the items of speculation and of instalment buying under the conditions which characterized affairs in this country during a few years past. These conditions led to unchecked high pressure selling of manufactured products associated with instalment payments, which (associated with reckless agriculture) had a considerable share in engendering the origins of financial panic and depression which are upon us. Neither bankers nor economists raised the voice of warning while industrial plant and industrial man-power in various industries were being expanded to the level required by a forced and over accelerated selling basis that inevitably led ultimately to stagnant markets caused by the margins of family incomes being absorbed in payments for past purchases. Engineers associated with the industries shook their heads in doubt over the situation, but they must also bear their share of responsibility because they did not raise their voices in argumentative protest. This may be an evidence of moral weakness in an unexampled situation, but precedents were lacking and perhaps we may pass that weakness over if suitable prevision is shown in the efforts for reestablishment of stability.

The committee is quite right in stating that investment bankers and the speculative public both had definite responsibilities in the matter. The engineers also had responsibilities and part of that responsibility must rest with the engineering schools on account of their failure to press effectively into economic philosophy a recognition of those features which distinguish the modern world from the world of Adam Smith, Hume, Richardo, John Stuart Mill, and their contemporaries of over a century and a half ago. Unless we thus modify our political economy, we are likely to lose the enviable standard of living and of intellectual activity which exists among the generality of our citizens.

One of the difficulties that the committee's report lays before us is associated with an inference that long-time planning should be a feature of industrial finance as well as government finance. The problem is to secure this important achievement without recourse to a degree of bureaucratic government control that verges on the edge of despotism, although perchance a benevolent despotism. A benevolent despot can do many things successfully, but we are not likely to approve such a guide for our lives even during the period of establishing a new political economy which is requisite to meet present conditions of our life which is wrapped up with the developments of science and invention of the last dozen decades. We must surely set up our economic situation in independence for ourselves, but this can be accomplished without refusing due consideration of mutual benefits which may arise from associated contacts with other countries. The discussion of the shorter-hour week in the report of the committee shows means for accomplishing this end and the general observations of the committee also are reassuring, provided those directly affected have been provided with convincing incentives for properly joining the satisfactions of leisure with the advantages of productivity. All who retain faith in the effectiveness of the human mind feel sure that this can be achieved.

The responsibility of devising serviceable measures for fending against the recurrence of depressions such as the present one, and their trains of hardship and suffering, rests upon those of us who live in this decade. To meet their part of this responsibility it is necessary for the engineers to bring to pass a cooperation which joins our scientific, pragmatic attitude to the philosophical tendency of the economists.

The engineering departments of our great educational institutions are well established in, and should continue to expand their creative work in, the borderland which overlaps with the natural sciences of mathematics, physics, chemistry, and biology. They also work actively, but are not equally well established, in the borderland which overlaps with economics. The latter borderland—contrasted with studying, investigating, and guiding phenomena of nature related to physical phenomena—consists in studying, investigating, and guiding the economic and social uses of structures, power, machinery, communication of intelligence and transportation, and guiding the influence of engineering on modes and conveniences of life. We have a good start in this, but with less intensive cultivation than on the mathematical-physics side. The appropriate manner of carrying on is by statistical and scientific investigation to establish facts and relations that are now perceived only dimly or perhaps not yet perceived at all. This cooperation should be and can be as fully established as on the mathematics-physics border. The object is to place this economics side of engineering on the same altitude of rigorous examination and reasoning as now characterizes the science side of engineering in the engineering schools. Collaterally, the object is to develop more rigorous investigation in this now neglected or only loosely studied field, while scrupulously avoiding any detracting from the efforts on the science side.

Besides leading their students to familiarity with the theoretical tenets of science and economics, the engineering departments in the engineering schools have the obligation to translate to the students a scholarly engineering vision of the principles of science and economics embodied in the works of man wrought in materials such as metals, stone, wood, and fiber, and the influence on civilization which is concomitant to those embodiments. "Machines, the slaves begotten of man's thoughts" have done us relative good, but until the articulation of engineering into economics is worked out in the engineering schools of university rank as fully as the articulation which now exists with mathematics, physics, chemistry, and biology, there will be danger of the relative good becoming relative evil. I do not charge this fault to the economists, theirs being a philosophical field; but as previously said we, the engineers, must bring to pass a cooperation which joins our scientific, pragmatic attitude to their philosophic tendency. From such cooperation brought to pass in engineering schools of high level, we may validly hope for the solution of such complex problems, for example, as the periodic recurrence of acute unemployment, and the ultimate formulation of effective means for prevention. Illumination may be secured on many other subjects, such as the perplexing subject of the responsibilities for mutual welfare which pertain between corporations, their employes and their stockholders, when both employes and stockholders may be in large numbers and both groups in general being composed of people of small means.

When the engineering departments have accomplished this cooperation in the institutions of university level and have secured a communion with the economists of a level and order equal to our communion with the scientists, we will have established our buttresses in both sides of the field of engineering and will be in position to cultivate most serviceably the full area of industrial science and economics. This method of securing a restudy of the tenets of political economy so that the structure of economics adapted to our present day mode of life may be erected is feasible, and it is so promising of important results that I hope that it may command support from the A.E.C. committee.

Very truly yours,
DUGALD C. JACKSON
(F'12 and Past-president)
(Massachusetts Institute of Technology, Cambridge, Mass.)

Reactive Power Units and Terms

To the Editor:

Mr. Irwin's letter (see ELECTRICAL ENGINEERING, August 1932, p. 597–8) calling attention to the disregard of the internationally adopted "var" as the unit of reactive power is very timely. As if to vindicate Mr. Irwin's admonition, there are published, on page 589–90 of the same issue, engineering abbreviations that are officially endorsed by the A.I.E.E. In this list the "var" is conspicuously missing, whereas the "rva" is duly displayed.

The relation between "rva" and "var" is obvious. In "var" the "r" that stands for "reactive," is put after the "va" instead of before. In this manner a name is obtained which not only is easily pronounceable, but also contains the elements of definition of the unit it stands for; which is more than can be said of the names of most of the established units.

"Var," therefore, seems a perfectly rational name for the unit of reactive power, and it is difficult to see on what grounds objection could be made to its general use which ought to be promoted by the A.I.E.E.

The unit most commonly applied in practise will, of course, be the "kilovar," abbreviated "kvar," which also is missing in the "standard" engineering abbreviations referred to. One need only compare the brief term "kilovar" with the lengthy "reactive kilovolt-ampere," or with the cacophonous spelled variety: "rkva," to become converted to the name adopted by the International Electrotechnical Commission.

Very truly yours,
ARTHUR A. BOLSTERLI (A'23)
(145 Church St., Hamden, Conn.)

Editor's Note: As a comment on the above letter from Mr. Bolsterli, the following quotations from a letter sent to sponsoring organizations by Preston S. Millar (M'13), secretary of the American Standards Association's sectional committee on scientific and engineering symbols and abbreviations, are presented herewith:

"To the appendix of International Electrotechnical Commission recommendations attached to the report of the subcommittee on abbreviations for scientific and engineering terms, dated June 1932, which was distributed on June 3, 1932, to the sponsor organizations and to the members of the sectional committee, and which was submitted on June 15, 1932, to the American Standards Association, the following 3 units and abbreviations have been added:

"var (reactive volt-ampere) .... var
"kilovar (reactive kilovolt-ampere) .... kvar
"kilovarhour (reactive kilovolt-ampere-hour) . kvarh

"These names of units and their abbreviations were officially adopted by the international Electro-

nical Commission at the plenary meeting held slo, July 9, 1930. The list of I.E.C. abbre- ons appended to the report of the subcommittee d June 1932, was taken from an I.E.C. pub- ion, which has not been revised since 1920. this reason the 3 above terms and their abbre- ons were unfortunately omitted. They are added in order that the appendix may accu- y represent the present day recommendations e I.E.C."

may be noted that the terms "var," "kilovar," "kilovarhour" were officially adopted by the rnational Electrotechnical Commission on 9, 1930. However, these terms are not con- nt with American practise and have not been ted as American standard. Therefore they not included in the list of American tentative dard abbreviations published in ELECTRICAL INEERING for August 1932, p. 589–90. Further ments on this subject are invited.

vercompounded D-C Generators Without an Equalizer

the Editor:

n this letter is discussed the division of l between 2 overcompounded d-c genera- when the equalizer circuit is opened. problem is not of importance practically has considerable theoretical interest, as been evidenced by the discussion used by the statement in "Direct Cur-

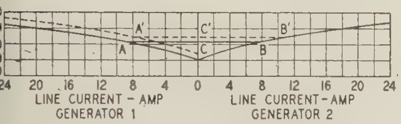


Fig. 1. Voltage regulation curves of 2 d-c generators each rated 3 kw, 115–125 volts, 24 amp, 1,700 rpm

t Machinery," written by Harold Pender published by John Wiley and Sons, that a given total line current, if the speed of generator increases after the equalizer been opened, the current output of that erator decreases, and, the action being ulative, the instability of operation hout an equalizer is thus explained. ong the 5 other texts, in English, which e been consulted, there is virtually nimous agreement that the converse ds, and the discussion mentioned above centered on this point.

'o review briefly the minority argument ch this letter attempts to justify further, sider Fig. 1, the voltage regulation ves (shown solid) of 2 generators supply- a total load current AB at a voltage when the current in the equalizer is zero. ning the equalizer will have no effect on the system until some mechanical or electrical property changes. If for some reason the speed of generator 1 increases, the corresponding voltage regulation curve (dashed in Fig. 1) will be above the former curve, and the total load current, if it has not changed appreciably, will be represented by $A'B'$ ($= AB$ in magnitude). Hence, since $A'C'$ is less than AC, the current output of generator 1 will have decreased despite the increase in speed of this machine.

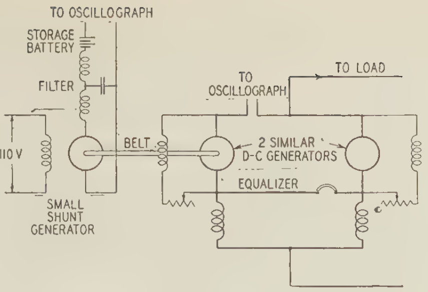


Fig. 2. Connections for the 2 d-c generators represented in Fig. 1

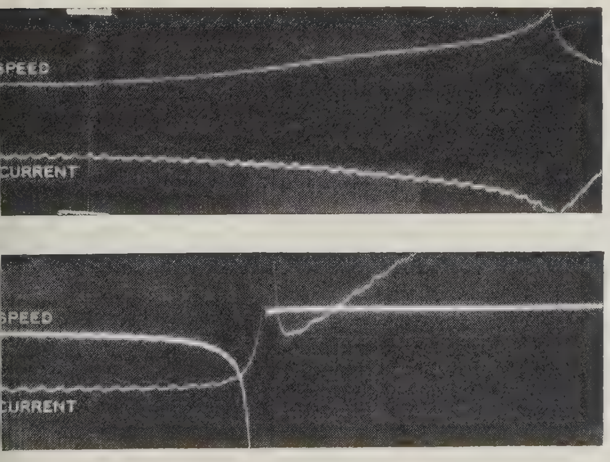
It is obvious that this argument can be only approximate, since the voltage regulation curves are determined for steady state conditions whereas the unstable condition of the system is essentially not a steady state condition. This has been the crux of many criticisms in which it has been contended that an increase in the speed of generator 1 increases the terminal voltage, hence causes that machine to increase its current output; the action is cumulative and consequently, according to this argument, the machine which increases speed ultimately carries all the load and may drive the other generator as a motor.

The oscillogram of Fig. 3 shows current and speed of one of a pair of similar generators (Fig. 2), the voltage regulation curves of which are pictured in Fig. 1. (Speed was measured by belting a small shunt generator to the machine and inserting a storage battery in the output circuit so that the voltage at the oscillograph was proportional to the difference between the actual speed and some datum near 1,700 rpm. An upward deflection of a curve on the oscillograms indicates an increase in the corresponding quantity.) The oscillogram is typical of many. It covers a time interval of 15 sec, and was obtained by simultaneously starting the photographic record and opening a circuit breaker in the equalizer, the current in the latter being zero. The portion of the oscillogram to the right of the peaks in the curves shows the readjustment following the reclosing of the circuit breaker in the equalizer. In this case the process took place comparatively slowly, the speed increasing while the current was decreasing. Fig. 4 shows the speed decreasing as the current increased. The action in this case took place rapidly after it was once started; the speed decreased sufficiently to cause a fuse in the corresponding oscillograph circuit to burn out, giving rise to the straight heavy curve in the right half of the figure, while the current, neglecting part of the curve due to overswing of the oscillograph element, increased rapidly and almost regularly.

These oscillograms show conclusively that the majority argument given in the third paragraph of this letter cannot be of universal application. It cannot be claimed, however, that the oscillograms prove completely the other point of view. The problem is one which depends on many factors—the system would be unstable without an equalizer if the speeds remained constant—but the oscillogram of Fig. 3 does indicate that for the particular case the changes took place so slowly, comparatively, that the analysis using the steady state regulation curves would be expected to indicate at least qualitatively the action.

Very truly yours,

J. G. BRAINERD (A'32)
(Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.)



Figs. 3 (Above) and 4 (Below). Oscillograms of machines shown in the diagram of Fig. 2

Engineering Foundation

A Reading List in Economics and Sociology

Engineers recently have exhibited a marked increase of interest in economics and sociology, and in the relation of engineering thereto. This interest appears to have become widespread and purposeful. To assist readers in these fields, The Engineering Foundation includes in its Research Narrative No. 190, the list of books and articles given below. The Engineering Foundation states that mention of a book in this list is not intended as an endorsement, nor should omission be taken to mean disapproval, nor has the order any significance. These books listed present varieties of subjects and views.

THE ENGINEER IN A CHANGING SOCIETY, W. E. Wickenden, ELEC. ENGG., July 1932, p. 465–71.

SOCIOLOGY OF CITY LIFE, Niles Carpenter, Longmans, Green & Co., New York, 1931. $3.90.

POPULATION PROBLEMS, Warren S. Thompson, McGraw-Hill Book Co., New York, 1930. $3.75.

THE INSTINCTS OF THE HERD IN PEACE AND WAR, William Trotter, The Macmillan Co., New York, 1930. $1.50.

THE EPIC OF AMERICA, James Truslow Adams, Little, Brown and Co., Boston, 1931. $3.75.

THE DIRECTION OF HUMAN EVOLUTION, Edwin Grant Conklin, Charles Scribner's Sons, New York, 1922. $2.50.

THE GREAT ANALYSIS, William Archer, Williams and Norgate, Ltd., London, 1931. 2 shillings.

OUR CHANGING CIVILIZATION, John Herman Randall, Jr., Frederick A. Stokes Co., New York, 1929. $3.00.

TAMING OUR MACHINES, Ralph E. Flanders, Richard R. Smith, Inc., New York, 1931. $2.50.

Progress and Poverty, Henry George, Baker & Taylor Co., New York, new edition 1931. $1.00.

Business vs. Finance, David Cushman Coyle, Published by author, New York, 1932. 60 cents.

Business Cycles, Wesley C. Mitchell, National Bureau of Economic Research, New York, 1927. $6.50.

The Growth of American Trade Unions, Leo Wolman, National Bureau of Economic Research, New York, 1924. $3.00.

Health and Wealth, Louis I. Dublin, Harper & Bros., New York, 1928. $3.00.

Pathways Back to Prosperity, Charles Whiting Baker, Funk & Wagnalls Co., New York, 1932. $2.50.

Jobs, Machines and Capitalism, Arthur Dahlberg, The Macmillan Co., New York, 1932. $3.00.

The Swope Plan (for Stabilizing Industry), Gerard Swope (edited by J. George Frederick), The Business Bourse, New York, 1931. $3.50.

New Roads to Prosperity, Paul M. Mazur, The Viking Press, New York, 1932. $2.00.

Emotion as the Basis of Civilization, Henry S. Dennison, Charles Scribner's Sons, New York, 1928. $5.00.

Emotional Currents in American History, Henry S. Dennison, Charles Scribner's Sons, New York, 1932. $5.00.

The World's Economic Dilemma, Ernest M. Patterson, McGraw-Hill Book Co., New York, 1931. $3.50.

The Tragedies of Progress, Gina Lombroso, E. P. Dutton & Co., New York, 1931. $3.75.

Toward Civilization, Edited by Charles A. Beard, Longmans, Green & Co., New York, 1930. $3.00.

Economic Behavior, 2 Vols., Atkins, Edwards, Friedrich, Houghton Mifflin Co., Boston, 1931. $8.50.

Laissez-Faire and Communism, John Maynard Keynes, New Republic, Inc., New York, 1931. $1.00.

What Price Progress? Hugh Farrell, G. P. Putnam's Sons, New York, 1926. $2.50.

Power Control, H. S. Rausenbush and Harry W. Laidler, New Republic, Inc., New York, 1931. $1.00.

New Russia's Primer, M. Ilin (translated by George S. Counts and Nucia P. Lodge), Houghton Mifflin Co., Boston, 1931. $1.75.

Impressions of Soviet Russia and the Revolutionary World, John Dewey, New Republic, Inc., New York, 1931. $1.00.

Piatiletka: Russia's 5-Year Plan, Michael Farbman, New Republic, Inc., New York, 1931. $1.00.

Research Procedure Committee Established

With the approval of the 4 principal engineering societies, and following a recommendation by the endowment methods committee of United Engineering Trustees, Inc., a research procedure committee has been established by The Engineering Foundation. The members of this committee appointed for the year 1932 and the societies which they represent are: Thaddeus Merriman, American Society of Civil Engineers; F. M. Becker, American Institute of Mechanical Engineers; W. H. Fulweiler, The American Society of Mechanical Engineers; L. W. Chubb (F'21), American Institute of Electrical Engineers; and E. DeGolyer, and D. R. Yarnall, Engineering Foundation.

The duties of this committee are to aid The Engineering Foundation in ascertaining and meeting the research needs of the 4 engineering societies and in making intelligent selections among the numerous projects in which these societies are individually and collectively interested.

Personal

P. H. Chase (A'12, M'18) chief engineer of the Philadelphia Electric Company, Philadelphia, Pa., will continue as chairman of the Institute's technical committee on power transmission and distribution for the year following August 1, 1932. Mr. Chase is a native of New Hampshire. He was graduated from Dartmouth College in 1907 with the degree of A.B., received the degree of S.B. in E.E. from Massachusetts Institute of Technology 2 years later, and the degree of M.E.E. from the Graduate School of Applied Science, Harvard University, in 1910. Following the completion of these studies he joined the Public Service Electric Company of New Jersey as assistant to the superintendent of distribution for Newark, N. J., and for the greater portion of 2 years had general supervision over the commercial and railway substations of the Newark district. In 1912 he was transferred to the company's engineering department, at first reporting to the electrical engineer in charge of electrical design and construction of power stations, but shortly advancing to the office of assistant engineer, his work covering all phases of estimating costs, preliminary and final design of power stations and substations, making up specifications, and the supervision of construction. For 4 years he was chief electrical engineer for the American Railways Company. He joined the Philadelphia Electric Company in 1921 as assistant engineer of the transmission and distribution division; in 1928 he was advanced to the position of engineer in charge of the division. Mr. Chase has been active in several of the representative engineering societies; in the Pennsylvania Electrical Association he has been, in turn, chairman of the overhead systems committee, technical section chairman, treasurer, vice-president, and for the year 1926–7, president. He is past chairman of the Institute's Philadelphia Section, holds membership in the National Electric Light Association, the Illuminating Engineering Society, and The American Society of Mechanical Engineers. He also is a member of the Engineers' Club of Philadelphia, the Penn Athletic Club, and the Philadelphia Country Club. Other committee work for the A.I.E.E. has included service as a member of the committee on protective devices 1918–25, standards 1917–22, and technical program 1930–32. His membership on the power transmission and distribution committee dates from 1924 continuing in unbroken service, his chairmanship dating from 1930.

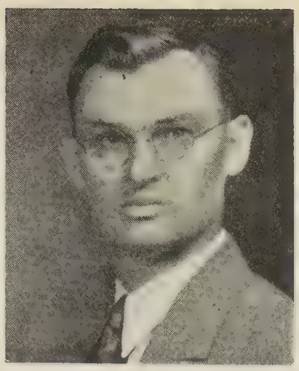
E. L. Moreland (A'11, F'21) of Jackson and Moreland, Consulting Engineers, Boston, Mass., has received his reappointment as chairman of the Institute's technical committee on transportation, to which he first was appointed in 1931. Mr. Moreland was born at Lexington, Va., and in 1905 was graduated from The Johns Hopkins University, Baltimore, Md., with the degree of A.B. in mathematics and physics. In 1908 he entered the employ of D. C. Jackson (A'87, F'12, and past-president) and W. B. Jackson (A'97, F'13) consulting engineers in Chicago, Ill., and Boston, Mass., and served as a personal assistant to Mr. D. C. Jackson, senior member of the firm. In 1912 Mr. Moreland was made manager of the Boston office of this firm, and in 1916 became one of the partners. From 1918 to 1919 he served first as captain and then major in the engineers corps, American Expeditionary Forces, on a technical board charged with the procurement of electrical and mechanical power for A.E.F. activities; also as technical executive on the War Damage Board, which was created to advise the American delegates to the Peace Conference with reference to damages to physical property caused in the allied countries by the war. Upon return from military service the partnership with D. C. Jackson was formed. The principal activities of the firm are as consulting engineers on the design and supervision of construction of power plants, and transmission and distribution systems for public utilities and large industrial plants; and on railroad electrifications, valuations, and rate investigations. Among the most conspicuous pieces of work handled by the firm recently have been the electrification of the Great Northern Railway through the Cascades and the electrification of the suburban service of the Lackawanna Railroad out of Hoboken, N. J. In Institute activities Mr. Moreland has served as chairman of the Boston Section; chairman of the electrical machinery committee's subcommittee on rectifiers, as well as on the full committee from 1929 to 1931; on the power generation committee 1929–31; and on the technical program committee 1931–32. He was the Institute's

P. H. CHASE

CHESTER W. RICE

E. L. MORELAND

F. O. SCHNURE



C. W. DRAKE

R. A. BEEKMAN

presentative on and chairman of the ctional committee on mercury arc recti-ers organized under American Standards ssociation procedure, and has served on e Institute's standards committee. Mr. oreland has contributed frequently to nstitute and other engineering publica-ons. He is a member of the Engineers' lub, both in New York and in Boston, and the University and City Clubs in Boston.

C. W. Rice (A'14, M'24) assistant to the ce-president in charge of engineering, eneral Electric Company, Schenectady, . Y., by recent appointment was made airman of the Institute's technical com-ittee on research. Mr. Rice, who is the n of E. W. Rice, Jr. (past-president of the stitute, a member for life, and honorary airman of the General Electric Company, henectady, N. Y.), was born at Lynn, ass., and removed to Schenectady after e consolidation of the Thomson Houston d Edison General Electric companies. rly schooling was through home channels d in small private schools; at the age of he entered the second form of the Albany cademy, Albany, N. Y., and in the fall of 06, Harvard University, from which he ceived his S.B. degree in 1910 and his .E.E. degree in 1911. The fall of 1911 he tered the testing department of the eneral Electric Company at Schenectady, d the following December joined the nsulting engineering department, where worked under Dr. C. P. Steinmetz. ne 1917 he was transferred to the com-ny's research laboratory, where his work s principally on submarine detection de-es, supersonic sound signaling, piezo-ctric devices, heat convection work, and no inconsiderable amount of radio re-rch investigation. He holds a number patents in these fields. In May 1927 he s again transferred, to become assistant the vice-president in charge of engineer-in the engineering general department, present office. Mr. Rice's contributions technical literature have been many. belongs to many representative pro-sional and scientific bodies, including e American Physical Society, the Ameri-Association for the Advancement of ence, the Institute of Radio Engineers, d the Acoustical Society of America, of of which he is a fellow; and a member the American Chemical Society and the tical Society of America. He is an en-siastic member of the Schenectady Glider Club and of the Edison Club. Mr. Rice has served the Institute on the following committees: educational, 1916–19; electro-physics, 1918–27; telegraphy and telephony, 1922–24; communication, 1924–28; and the research committee of which he has just been made chairman, 1928–32.

C. W. Drake (A'20, M'21) general engineer of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., will continue to serve the Institute's technical committee on general power applications as its chairman for the coming year, in accordance with recent reappointment. Mr. Drake was born and educated in the city of Worcester, Mass., receiving his B.S. in E.E. from Worcester Polytechnic Institute in 1905. Leaving the New England section, he identified himself with the Westinghouse Electric and Manufacturing Company, at East Pittsburgh, and for the greater portion of 9 years worked with that organization's sales department as commercial or industrial engineer. In 1914 he was transferred to the Chicago office of the company, still as industrial engineer, but in 1919 returned to East Pittsburgh as general engineer of the industrial motor section. Since 1908 he has been in responsible charge of power and motor layouts for numerous industrial plants, paper mills, cement plants, and rubber mills. His work covered also the making of reports and estimates and supervision of installations and tests, leading to developments for special application of new types of drives and controls. He also did considerable work with central stations, assisting them in building up their motor load. The carrying out of tests and investigations took him practically to all parts of the United States. For over a year he had charge of a section of the Westinghouse company which was devoted to general engineering on electric welding, oil well machinery, and sugar mill equipment. His committee work with the A.I.E.E. includes 3 years on the committee on industrial and domestic power, 8 years on the general power applications committee, and 2 years on the technical program committee.

F. O. Schnure (A'23) who since 1916 has been identified with the Bethlehem Steel Company, Sparrows Point, Md., where he is now electrical superintendent, has been chosen as chairman of the Institute's technical committee on applications to iron and steel production for the current year. Mr. Schnure was born at Milton, Pa., and was graduated from Bucknell University with his B.S. in E.E. in 1914; his E.E. degree was conferred upon him in 1919. For a short period during 1914 he was with New York Railways as inspector of subway conduit construction. Then he joined D. C. and W. B. Jackson of Boston, Mass., as inspector and supervisor of overhead lines and power house appraisal of the Public Service Electric Company of New Jersey. The latter part of 1915 he joined the Pennsylvania Railroad Company at Altoona, Pa., as draftsman on power house design and layout. This was his position immediately preceding his joining the Bethlehem Steel Company, which he entered for miscellaneous electrical test work on maintenance and construction. After a year and a half in charge of electrical layout on a 50,000,000 dollar steel plant extension and $2^1/_2$ years as general foreman of electrical construction, he became foreman of the electrical repair shops. From this position he became assistant superintendent of the electrical department, later to be made superintendent, the office which he now holds. Mr. Schnure is also a member of the Institute's power generation committee, 1931–33, and in 1930 was elected president of the Association of Iron and Steel Electrical Engineers, a body in which he has been active over a considerable period of years, having served as chairman of its Philadelphia section in 1926–27, as a member of various of its committees. While in Baltimore, he served upon the executive committee of the A.I.E.E. local Section; also as a member of the educational committee of the Baltimore Chamber of Commerce during the years 1928–32. He has been a frequent contributor to technical literature both in papers before these several associations as well as through the technical press, writing on a variety of subjects dealing with the application of electricity to the steel industry.

R. A. Beekman (A'13, M'27) engineer of the federal and marine department of the General Electric Company, Schenectady, N. Y., continues for the ensuing year as chairman of the Institute's technical committee on applications to marine work. Mr. Beekman is a native of St. Louis, Mo., and received his B.S. in E.E. from the University of Missouri in 1910. July of that year he entered the testing department of the General Electric Company, from which he was transferred to the marine engineering department, now the federal and marine department. He holds several patents appertaining to electric ship propulsion; is a member of the Naval Architects and Marine Engineers, and has served on the Institute's committee on marine work since 1919, having been chairman since 1930. He also has been the Institute's representative on the American Marine Standards Committee since 1926. As chairman of the Institute's marine committee he is automatically a member of the Institute's technical program committee. Intimately associated with the General Electric Company's marine activities since 1912, he has spent considerable time at sea.

W. S. Culver (A'28) who for 47 years has been in the employ of the General Electric Company and its predecessors, and whose latest position with that company has been as district engineer of its East Central district with headquarters at Cleveland, Ohio, has retired from active service effective October 1, 1932. Mr. Culver has been a pioneer in the electrical industry, his first outside work being the installation of a 35-light incandescent generator. He was a close friend of Charles Francis Brush, of Cleveland, Ohio, the first man to bring out a commercial arc light system in this country and the founder of the old Brush Electric Company, Mr. Culver's first commercial connection in 1885. Mr. Culver also has spent considerable time in Manila installing electric light plants there. Upon his return to the United States he worked for awhile at the General Electric Company's Lynn plants, going to the central district then located in Cincinnati, Ohio, in 1902. His appointment as district engineer took place in 1907.

C. F. Hirshfeld (A'05) who is chief of the research department of the Detroit Edison Company, Mich., has been chosen vice-president of The American Society of Mechanical Engineers, an organization of which he has been a member since 1905. Always active in committee work, Doctor Hirshfeld has served the National Electric Light Association as chairman of its prime movers committee and of its engineering national section. For several years he was a representative of the electric light and power group of the American Standards Association; he has served on many committees of the A.S.M.E. In the committee work of the Institute, Doctor Hirshfeld has served on the following: industrial and domestic power, May–August 1922, power stations 1922–24, power generation 1924–31, standards 1923–30, and electrical machinery 1926–27. The degree of doctor of engineering was conferred upon him by Rensselaer Polytechnic Institute, Troy, N. Y., June 1932.

T. W. Carraway (A'21, M'32) who was vice-president of the Schwitzer-Cummins Company, Indianapolis, Ind., was transferred to Providence, R. I., as manager of the unit cooler department of the Grinnell Company, Inc., when the unit cooler, unit heater, and automatic valve business of Schwitzer-Cummins was purchased by Grinnell. Mr. Carraway has been unusually successful in the design and development of unit coolers and automatic equipment and is inventor of the Carraway automatic packless valve.

L. E. Underwood (A'03, M'13) who has been serving the General Electric Company at Lynn, Mass., as managing engineer of the stationary motor engineering department now has been appointed manager of the Pittsfield (Mass.) works. Mr. Underwood initiated his service in the stationary motor engineering department in 1899; was made chief engineer in 1915, and in 1927 managing engineer of the consolidated motor department in charge of engineering and manufacturing.

J. E. H. Stevenot (A'13, M'17) vice-president and general manager of the Philippine Long Distance Telephone Company, Manila, P. I., by executive orders issued by Governor-General Theodore Roosevelt under date of July 14, 1932, was made a member of a special committee on coordination of electrical communications in the Philippine Islands. This committee will meet at least once every month and submit its report to the Secretary of Commerce and Communications.

C. S. Lumley (A'23, M'29) who was electrical engineer for Smith, Hinchman and Grylls, Detroit, Mich., recently removed to Brookline, Mass., to become executive engineer of the Longwood Towers Corporation. Mr. Lumley has been with the Detroit interests, in charge of the municipal power plant project for the past 6 years; he also was chairman of the Institute's Detroit-Ann Arbor Section and a member of its membership and meetings and papers committees.

G. C. Neff (M'16) vice-president of the Wisconsin Power and Light Company, succeeds M. J. Insull (A'99) as president of the Middle West Utilities Company, Chicago, Ill., according to information recently made public. Mr. Neff has been chief operating executive of the Wisconsin Light and Power Company for several years. He has been active in the National Electric Light Association and in the promotion of rural electrification.

J. M. Barry (A'11) heretofore vice-president in charge of operation for the Alabama Power Company, Birmingham, Ala., recently succeeded to the office of vice-president and general manager. He has been with the company since 1923, when he became manager of its southern division; thereafter he was made manager of retail operation, and in May 1927 he took up his duties as vice-president in charge of operation.

C. W. Fick (A'16, M'25) who has been serving the General Electric Company's East Central district at Cleveland, Ohio, as assistant district engineer, effective October 1, 1932, became district engineer, succeeding W. S. Culver (A'28), retired. Mr. Fick prior to becoming assistant to Mr. Culver was northwestern engineer for the General Electric Company at Portland, Ore.

C. W. Adams (A'20) formerly with the United States Graphite Company of Saginaw, Mich., became affiliated on September 15, 1931, with the Speer Carbon Company of St. Marys, Pa., in the capacity of sales and consulting engineer at Saginaw, Mich. (Electrical Engineering for August 1932, p. 603, erroneously stated Mr. Adam's position and address.)

W. S. Gifford (A'16) president of the American Telephone and Telegraph Company, New York, N. Y., under date of August 5, 1932, withdrew from his work as active director of the President's organization on unemployment relief at Washington, D. C., and will again devote his full time to the office of president of his company.

J. E. E. Royer (A'15) who recently became vice-president as well as general manager of the Washington Water Power Company (Electrical Engineering, July 1932, p. 530) at a recent meeting of the Northwest Electric Light and Power Association was elected president of that organization.

Gerald Deakin (A'07, M'13) formerly vice-president and European technical director of the International Standard Electric Corporation at London, has returned to New York City to become technical director in charge of manufacturing and laboratory companies of the International Telephone and Telegraph Corporation.

E. H. Pemberton (A'32) who in the spring of 1931 was graduated from the General Electric Company's general course consisting of higher studies in electrical engineering and principles of business and management, now is teaching mathematics and physics at the Las Animas High School, Las Animas, Colo.

J. J. Albright, Jr. (A'21) previously manager of the power distribution central division of the Niagara Hudson Power Corporation, and more recently with the Niagara Lockport and Ontario Power Company at Syracuse, N. Y., now has joined the Syracuse Lighting Company of that city.

P. M. Downing (A'98, M'08) first vice-president and general manager of the Pacific Gas and Electric Company, San Francisco, Calif., recently was appointed chairman of the national sales section, an outgrowth of the former commercial section, of the National Electric Light Association.

Albert Brunt (A'14) who for some time has been director of the Societa per Construtioni Elektromechaniele di Saronno, Saronno, Italy, recently returned to Holland where he graduated from the Delft University in 1906, to become export manager of the Werkspoor, at Amsterdam.

Dean Harvey (A'04, M'13) has been chosen by The American Society for Testing Materials to serve as its chairman of committee B-4 on electrical heating, electrical resistance and electric furnace alloys. He also is vice-chairman of its committee D-9 on electrical insulating materials.

Alex Dow (A'93, F'13) president of the Detroit Edison Company, and a past-president of The American Society of Mechanical Engineers, has been appointed chief of the Detroit Ordnance District, a most important locality in Ordnance industrial procurement organization.

Thomas Spooner (A'12, F'29) manager of the central division research laboratories

the Westinghouse Electric and Manu- cturing Company, East Pittsburgh, Pa., cently became chairman of the American ociety for Testing Materials committee -6 on magnetic properties.

H. S. Vassar (A'06, M'18) laboratory ngineer of the Public Service Electric and as Company, Newark, N. J., recently was ade a member of the executive committee The American Society for Testing Mate- als. His history with his present company ates from the year 1903.

H. V. Dobson (A'28) city electrical in- ector for Santa Barbara, Calif., was chosen serve as chairman of the committee in arge of arrangements for the annual con- ention of the International Association of lectrical Inspectors held in Santa Barbara eptember 12–14, 1932.

M. V. Watson (A'07) vice-president and eneral manager of the West Coast Power ompany, Portland, Ore., at a recent meet- g of the North West Electric Light and ower Association was elected a member-at- rge of the executive committee to repre- nt utilities.

A. S. Moody (A'09) northwestern mana- r of the General Electric Company, Port- nd, Ore., was elected a member-at-large the executive committee of the North- est Electric Light and Power Association, Portland, Ore., to represent the manu- cturers.

C. W. Bates (A'08, M'13) who for the st year or so has been in the research epartment of Leeds and Northrup Com- ny, Philadelphia, Pa., in August 1932 ecame a member of the technical staff of he Franklin Institute Museum in that ty.

A. B. Day (M'16) president and general anager of the Los Angeles Gas and Electric orporation, Los Angeles, Calif., is a mem- r of the recently appointed executive com- ittee of the Pacific Coast division of the ational Electric Light Association.

H. L. Curtis (A'21, F'26) principal ysicist of the United States Bureau of andards, Washington, D. C., recently sumed the chairmanship of the American ciety for Testing Materials committee -9 on electrical insulating materials.

L. T. Merwin (A'10) vice-president and neral manager of the Northwestern ectric Company, Portland, Ore., was med vice-president of the Northwest ectric Light and Power Association at the ecutive meeting July 30, 1932.

Frederick Aemmer (A'27) who has been ving the New York Edison Company, w York, N. Y., as assistant engineer, ently was made operating manager of aftwerke, Oberhasli Power Company, nertkirchen, Switzerland.

E. W. Feller (A'27) who has been in the operating department of the Pennsylvania Water and Power Company at Holtwood, Pa., has gone to Safe Harbor, Pa., to join the operating department of the Safe Harbor Water Power Corporation.

A. S. Goldman (A'28) who was formerly purchasing agent for the People's Light and Power Corporation, New York, N. Y., recently was made division manager of the California Public Service Company, at Fort Bragg, Calif.

R. W. MacGregor (A'30) who at one time was affiliated with the International General Electric Company, at Schenectady, N. Y., now is in the commercial department of the Winters National Bank and Trust Company, Dayton, Ohio.

Tom Hairston (A'30) who has been associated with the Public Utilities Commission of the District of Columbia, Washington, D. C., recently accepted a position with the Gustav Hirsch organization of Columbus, Ohio.

H. E. Dexter (A'14, M'17) who for some years has been assistant general commercial manager of the Central Hudson Gas and Electric Company, Poughkeepsie, N. Y., recently appointed as its general commercial manager.

H. K. Munroe (M'17) who was vice-president of the Continental Pipe Manufacturing Company, Seattle, Wash., now is vice-president of the American Plumbing and Steam Supply Company, Tacoma, Wash.

R. F. Pack (A'11, M'12) president of the Northern States Power Company, Minneapolis, Minn., has received appointment to chairman of the rehabilitation committee of the Ninth Federal Reserve District.

H. L. Paulding (A'31) who for some time has been interested in the development of printing telegraph apparatus, recently became electrical engineer of Dow, Jones and Company, Inc., New York, N. Y.

E. A. Wagner (A'08, F'27) has retired from the office of manager of the General Electric Company's Pittsfield works, as recently announced through company channels.

L. B. Bender (A'20, M'27) major of the Signal Corps, U.S. Army, Army War College, Washington, D. C., has been transferred to Fort Hayes, Columbus, Ohio.

J. T. Danko (A'31) has removed from McKeesport, Pa., to become instructor in mathematics and electricity at the Aliquippa (Pa.) high school.

R. A. Menendez (A'31) recently became assistant to the electrical engineer of the Harnischfeger Corporation, operating in the city of Milwaukee, Wis.

Obituary

Magnus Washington Alexander (A'12, M'14) for the past 16 years president of the National Industrial Conference Board, Inc., New York, N. Y., died at his home in New York City on September 10, 1932, of heart attack. He was 62 years of age. Doctor Alexander was a native of New York City, but his general education was acquired in Vienna, Austria, first attending gymnasium there and later a college of mechanical engineering and mining academy for metallurgical engineering. In 1894 he joined the Weston Electrical Instrument Company, Newark, N. J., as draftsman, changing the following year to become draftsman and section chief draftsman on d-c motors and generators, and transformers for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. In 1899 he removed to Chicago to become chief draftsman for the Siemens Halske Electric Company for one year, after which he joined the General Electric Company, West Lynn, Mass., first as engineer in charge of the drawing office for 8 years and then on economic and executive work, including educational activities. His service with the General Electric Company extended over a period of 18 years. In 1918 he was made engineer on economic issues in a consulting capacity. In 1916 he helped to organize the National Industrial Conference Board, devoted to industrial planning and research, and by 1919 he was giving the major portion of his time to its development. In 1920 the board moved its offices from Boston, Mass., to New York City, but during a portion of the 4 years just prior to his return to New York, Mr. Alexander was prominent also as chairman of the Massachusetts Commission on Old Age, Annuities and Pensions and as a member of the Massachusetts Commission on Compensation for Industrial Accidents. As the scope of the industrial conference board broadened, Mr. Alexander more and more assumed the rôle of spokesman for some of the greatest industries of the nation. In Washington in 1919 he opposed the principle of collective bargaining between capital and labor. In 1918 Mr. Alexander opposed the circulation of a school book called "Lessons in Community and Private Life" the foreword of which was written by President Wilson, the basis of his opposition being that it taught the children to favor social insurance, labor unionism, and governmental control of private activities. In November of 1930 Mr. Alexander criticized the retailers for not having cut their prices, stating that "when retail prices have reached a sufficiently low level and not sooner will there be a distinct inducement for the public to buy." Last April, in addressing the graduating class of the General Society of Mechanics and Tradesmen, he said, "When all is said and done the conclusion would seem to be justified that the basic cause of the recent colossal collapse was overindulgence in the expansion of industrial plants and equipment, in production, in stimulation of production by excessive advertising, high-pressure salesmanship and instalment selling; overindulgence in spending, and overindulgence in speculation."

Grover Cleveland Sutton (A'11) a member of the Institute's Spokane Section and at the time of his death vice-president of the General Machinery Company, Spokane, Wash., died in that city August 2, 1932. Mr. Sutton was a native of Worton, Md.; he studied electrical engineering first by a correspondence school course; then attended Washington College at Chestertown, Md., from which he won his A.B. degree, and still later studying at Carnegie Institute of Technology, then known as the Carnegie Technical Schools. His first commercial affiliation was as chief engineer of the Chestertown Electric Light and Power Company, Chestertown, Md. This was during his last 2 years at college. In 1907 he became an engineering apprentice with the Westinghouse Electric and Manufacturing Company, at Pittsburgh, Pa., and 2 years later was sent to Spokane, Wash., as salesman for this company. The years 1910–12 were spent as erecting and operating engineer in saw mill electrification, after which he became purchasing agent for saw mill, logging, and all related operations. In this capacity he was responsible for all engineering in connection with an extensive logging and lumber manufacturing business, advising as to the necessity of purchase on all matters coming within his jurisdiction.

Charles Shirley McGill (A'21) who has been serving the Delaware Power and Light Company of Wilmington, Del., as plant superintendent, died the latter part of August 1932. Born at Leesburg, Loudoun County, Va., Mr. McGill attended the Leesburg Academy, and later the East High School in Washington, D. C. He took a private course in higher mathematics under Prof. Brantz Rossell at Johns Hopkins University, and further studied mathematics and electrical engineering by correspondence. In 1895 at the age of 18 he became a shop apprentice with the Metropolitan Railway Company, Washington, D. C., remaining there until 1897 when he was engaged as a switchboard operator by the Columbus Edison Company at Columbus, Ohio. In 1900 he left Columbus to accept work as apprentice and salesman of the Westinghouse Electric and Manufacturing Company, to operate both at Pittsburgh, Pa., and Baltimore, Md. Four years later the Houston Coal and Coke Company of Elkhorn, W. Va., made him its chief electrician; he simultaneously performed like duties for the Thacker Coal and Coke Company, at Thacker, W. Va., installing and placing in operation power house and mine haulage for these 2 companies. In 1907 the Western Electric Company, Cincinnati, Ohio, made him assistant sales manager, but in 1909 he changed to become sales engineer for Allis-Chalmers Manufacturing Company, Cleveland, Ohio. Returning again to Cincinnati in 1911 he became branch manager of the Crocker-Wheeler Company, 4 years later to return to the Allis-Chalmers Manufacturing Company, this time at Huntington, W. Va., as branch manager. In 1916 he took up power engineering with the Wilmington and Philadelphia Traction Company, and a year later was advanced to the office of electrical superintendent.

Max Kushlan (A'28) electrical squad chief of the New England Power Construction Company, Mattapan, Mass., died in Boston, Mass., August 1932, following an operation. He was born at Minsk, Russia, but came to the United States at an early age and attended the English High School at Boston, Mass., Tufts College, at Medford, Mass., and the Massachusetts Institute of Technology, Cambridge, Mass., from which latter institution he received his S.B. degree. From 1909 to 1910 he was a cable tester for the Boston Elevated Railway Company; then he joined Stone and Webster, Inc., as a draftsman remaining with this organization until 1912 when he went as assistant mechanical engineer to the Goldschmidt Detinning Company, East Chicago, Ind. Remaining there until 1913, he joined Sargent and Lundy, Chicago, Ill., as electrical draftsman; 2 years later he became engineering draftsman for the City of Chicago. In 1916 his title was changed to designing engineer, city of Chicago, and he was made assistant to the head of the division of bridges, in responsible charge of design of mechanical and electrical equipment for bascule bridges, his work including reports and specifications. The year 1920 found him electrical engineer of the Bascule Bridge Company, Chicago, directing electrical design work in the office and supervising the work in the field. He also represented his firm at conferences with clients. In 1921 he established his own business as engineer and contractor, but the following year joined the Brooklyn Edison Company, Brooklyn, N. Y., as electrical checker, a service which he continued until 1923, when Stone and Webster, Inc., made him its electrical designer in responsible charge supervising and checking electrical drawings and estimates in connection with power station design. Mr. Kushlan was the author of "The Gas Motor" and "Freehand Drawing," and contributed articles to technical magazines.

James Andrew Shepard (A'13) assistant general manager of the Roan Antelope Copper Mines, Ltd., Luanshya, Northern Rhodesia, died July 13, 1932, following a hospital stay of some 10 days. He was born in Deming, New Mexico, in 1889 and was graduated as an electrical engineer from the Rose Polytechnic Institute, Terre Haute, Ind. From there he entered the electrical department of the Detroit Copper Mining Company, Morenci, Ariz. Upon leaving Morenci, Mr. Shepard served the Public Utilities Companies in Deming and Tucson, Ariz., and was later appointed manager of the Bisbee-Naco Water Company. In 1926 he joined the Phelps Dodge Corporation at its Copper Queens branch at Bisbee, Ariz., first as assistant general manager, and when the general superintendent was transferred to Northern Rhodesia, Mr. Shepard took over his duties. In 1929 Mr. Shepard went with the Roan Antelope Copper Mines, Ltd., as assistant general manager, where he was greatly respected by every one with whom he came in contact.

Local Meetings

Future Section Meetings

Dallas

October 17—Vibration of Electrical Conductors, by R. A. Monroe, Aluminum Co. of America. Illus.

Lehigh Valley

October 14—Electrons at Work and Play, by Phillips Thomas, Research Engr., Westinghouse Elec. & Mfg. Co. Meeting to be held at the Traylor Hotel, Allentown, Pa.

New York

October 14—Opening meeting of power group; meeting devoted to "Serving the Electric Consumer." The utility's problem will be presented by H. R. Searing, The New York Edison and United Electric Light and Power Companies, while the contractor's problem will be discussed by Allan Coggeshall, President, Hatzel and Buehler, Inc. Discussion of items such as demand factor, power factor, voltage requirements, motor starting currents, and attendant costs will illustrate that each of the 2 agencies, utility and contractors, must work with an understanding and appreciation of the functions and problems of the other, in order that service of a high standard may be rendered. The meeting will convene at 7:30 p.m., and will be adjourned promptly at 9:30. Non-members are welcome. Discussion is open to all. The location will be Room 1, Fifth Floor, Engineering Societies Building.

Pittsfield

November 1—Japan, China, and the White Man, by Upton Close.

November 15—Air Conditioning—Perfect Weather in Your Home 365 Days a Year.

Past Section Meetings

Mexico

Vacuum Tubes and Applications to Industry, by C. Santacruz, Genl. Elec. Co. Illus. Dinner. Aug. 26. Att. 42.

Milwaukee

Public Works, by Maj.-Genl. Lytle Brown, U.S. Army. Joint meeting with the Engrs. Soc. of Milwaukee.

Pittsfield

Excursion. Aug. 31. Att. 227.

Spokane

Adventures in Science, by E. L. Manning, Genl. Elec. Co. July 1. Att. 450.

Toledo

Discussion of activities for coming year. Sept. 9. Att. 27.

Past Branch Meetings

University of California

Dr. L. E. Reukema, counselor, reported on the summer convention held at Cleveland, O. Dr. L. F. Fuller outlined changes and activities in the elec. engg. dept. during the coming year. Motion pictures. Aug. 24. Att. 70.

Drexel Institute

The Therapeutic Value of X-Rays, by Edward Cliver, student. Aug. 16. Att. 7.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

E.E., grad., 35, married; 19 years experience as ctrician, construction foreman, substation opera-. Elec. welding experiments; 3 yr. utility, afting and engg.; $3^1/_2$ yr. Western Elec. mech. d elec. designs. Wiring diagrams and genl. lustrial plant construction. Best references. andinavian languages. D-1393.

GRAD. E.E., 29; 5 yr. supervisory construction, sign, estimating, and field engg. experience on per-pwr. plants and substations; 4 yr. industrial r. plant operation, elec. construction and main- nance experience; ry. electrification construction perience. C-4428.

PRACTICAL ELEC. CONSTR. CHIEF, 32, gle, 14 yr. experience in construction also main- nance work. Last 4 yr. in Latin America. Can eak Spanish and German fairly well. Available mediately. Location, immaterial. C-2101.

YALE GRAD., 1927, B.S. in E.E., desires engg. sition or teaching, $1^1/_2$ yr. experience testing ry. equip.; $3^1/_2$ yr. design and application of outside nt hardware in natl. utility. Also experience in eration of small pwr. plant. Location preferred st. D-1305.

ELEC. CONSTR. ENGR., with 10 yr. practical perience in elec. constr. of new and old bldgs., luding estimating, field engg. and designing. ve had complete charge of elec. constr. on many lgs. in N. Y. City and can furnish the best of erences. Available at once. A-850.

Consulting

CONS. ENGR., Grad. E.E., 31, with Am. and Am. experience in distribution and transmission sign and construction, appraisals, meters, testing, rchases and stores, and pwr. sales. Desires ening in consulting office. Location, immaterial d salary secondary. D-1383.

Design and Development

E.E., 31, single, Am., 4 yr. experience in design sound reproducing equip., 5 yr. of practical ry. naling work in field and office, part in foreign untries, speaks and writes German, Spanish and ench, wishes engineer's position in the elec-mech. d, location anywhere. Available immediately. 5056.

SWITCHBOARD DESIGNER, 29, married, 6 experience in design of a-c. and d-c. pwr. plant itchboards, motor controls, wiring schemes, itchboard: estimating, sales, erection supervision d engg. Also 3 yr. experience on manual and tomatic tel. switchboards. Desires position as signer, estimator or sales engr. Location in East eferred. D-1423.

ELEC. DESIGNER, 30, married, 5 yr. experi- ce with telegraph company, competent drafts- n; speaks Spanish correctly and fluently. Will ept domestic or foreign location. Available at ce. D-1442.

E.E., 10 yr. experience. B.S. Worcester P. I. 22. E.E. 1924. A'25, M'32, Section chm. '32 .E.E. Single, 32, 8 yr. experience Westing- use transformers and auxiliaries, 2 yr. executive perience. Possesses inventive and natural abil- , personality and adaptability. Capable of uming responsibility. Location, immaterial, w England preferred. D-1443.

ELEC. DESIGNER, 32, married, equivalent of education, best of references, 14 yr. experience design of hydroelectric and steam pwr. plants, o. ry., high and low tension substations and tension network systems. Available at once. cation, immaterial. B-8628.

E.E. GRAD., 30, married 5 yr. with Westing- use design and application of protective relays, yr. with utility as switchboard designer and dred work. Desires position with utility or . Location preferred, Southwest, but any- ere acceptable. Available immediately. D-1476.

B.S. in E.E. 1929. 34 months of Westinghouse including industrial motors, large generating paratus and ry. motors. Interested in securing osition with a large industrial concern or utility. Location vicinity of New York. Available immediately. D-1455.

Executives

E.E., univ. grad., 4 yr. experience, drafting, design, construction and engg. of modern hydro and steam pwr. plants, substations and ry. electrification, $5^1/_2$ yr. with leading mfg. concern in engg. of automatic and manual switchgear equip. Foreign languages. Desires position with utility, engg., mfg. or ry. concern. Location, immaterial. B-7938.

ELEC. AND ILLUM. ENGR., Mem. A.I.E.E., I.E.S., 26 yr. experience commercial and industrial wiring and construction. Would like to connect with progressive contractor; estimating, engg., supervising, soliciting and selling work on quality rather than on price. Moderate salary to grow with business. Any location. C-8460.

E.E. GRAD., 29, married, 7 yr. broad experience, powerhouse, substation and transmission line design; major apparatus application, cost estimate, and equipment specifications. Excellent references. Desires connection with holding company, utility or mfr. D-678.

CHIEF ENGR., 42, married, practical, aggressive executive, with 20 yr. experience in design, development, production, sales and application of elec. material handling and factory equip. Available now. A-445.

ASSOC. A.I.E.E., B.E.E., '21, 39, single, $2^1/_2$ yr. additional study civ. engr.; 3 yr. steam R.R. valuation, elec. and mech. branch; 11 yr. track dept., large st. ry. property. Field engr., track supervisor and asst. to supt. maintenance; 5 yr. estimator track constr. semi-working knowledge spec. trackwork design. Location optional. D-1392.

TO AM. ENGG. CONCERNS operating in Spanish speaking countries—B.S. in E.E., 1929, single; 3 yr. genl. engg. experience, including erecting and testing pwr. equip.; conducting illum. and voltage surveys. Can speak English and Spanish equally well. Tech., administrative type of individual. D-1462.

E.E., M.E., 22-yr. experience, designing, constr. pwr. plants, substations, transmission, distribution systems, and industrial plants. Three yr. charge purchasing engg. equip., foreign interests; 3 yr. exec. experience charge engg. dept. large utility. English, German, Russian, Armenian, Turkish languages. Available immediately. D-84.

E.E., 34, 10 yr. experience covering design, cost estimating and equip. specifications of pwr. plants, copper refineries, indoor and outdoor substations, transmission lines and industrial work. Also 1 yr. experience as asst. research engr. with cable co. C-5473.

E.E., grad., 34, single; 7 yr. experience with utilities, estimating and designing transmission lines, substations and distribution systems; also reports and valuation of elec. properties. Speaks and reads German. Available immediately. Location, immaterial. B-8649.

ENGR. EXEC., M.E., M. I. T. grad.; 17 yr. broad experience in mfg. design and layout of plants; maintenance, mgmt. of machine shops, foundries, woodworking plants and other industrial plants. Purchasing. Traveled as mfrs. representative abroad. Knowledge of Russian, German. B-2589.

E.E. also B.S. in M.E. and C.E., 37; married. Splendid 15-yr. record of engg. accomplishments including design, development, application, supervision and exec. charge. Best reference. Desires opportunity where education and experience will prove valuable. Correspondence invited for more particulars. D-1494.

EXEC., univ. grad., 16 yr. experience in engg., mfg. and sales. Will consider proposition on salary or salary and commission basis. Location any place in U. S. A., although New York or vicinity preferred. Available at once. Prepared to travel. A-3946.

GRAD. ELEC., HYDROELEC. ENGR., 31, married, 2 yr. experience marine elec. installation; 8 yr. design, construction of steam, hydro pwr. plants, outdoor, indoor substations, transmission, distribution lines, wiring diag., indus. plants, office bldg., estimating, preparation of specifications. Desires position, utility, cons. engg. firm, industrial concern. Consider any location. Available immediately. D-212.

Inspection

ELEC. GRAD., 38, single; 6 yr. experience factory testing—W. E. & M. Co., E. Pittsburgh, Pa.; 1 yr. steel co. installing and testing elec. equip. Six months factory inspection of transformers, $2^1/_2$ yr. genl. inspection of elec. equip. with insurance co. Good reference. Available immediately. Any location. D-1461.

Instruction

E.E. GRAD., 1929; 3 yr. instructor of economics of engg. Grad. work in economics and business administration. Desires to teach economics and related subjects to engrs. or to get into any kind of engg. mgmt. Available immediately. Location, immaterial. D-1405.

PHYSICIST, 49, married, Ph.D.; 7 yr. univ. teaching experience, Yale, U. of Ill.; 1 yr. study Rutherford, Eng.; 15 yr. experience, directing, carrying on research in heat transmission and phases elec. and mech. lines 2 large industrial concerns. Present position being discontinued. Desires position of responsibility, univ. teaching or industrial research. D-1366.

Junior Engineers

E.E. GRAD. with honors, 1932, Ala. P. I., 23, single. Speaks fluently Greek and English. Desires experience and is willing to work. Worked way through col. Excellent references. Interested in sales work. Glad to hear from you. D-1384.

ELEC. INSTRUMENTS, 6 yr. mfg. experience pyrometer indicators, controllers and recorders, specialized on galvanometer construction. B.S. 1922 chem. engg., Pennsylvania St. Col. At Columbia 1931–1932 studying elec. and physics. Single, 31. Any line elec. mfg., testing, etc. Location, New York or East. D-1382.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge, repeated only upon specific request and after one month's interval. Names and records remain on file for three months, renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra three-cent stamp enclosed for forwarding.

GRAD. E.E., Rensselaer P. I., 1932; 22; single. Desires any kind of work in the elec. field. Location, immaterial. Available at onec. D-1397.

MOVING PICTURE SOUND staff position desired by Carnegie Tech grad. (1932). Prefers position with an opportunity for research in the transmission of moving pictures, 8 yr. experience as moving picture operator (present employment). Experienced in taking pictures and developing films. Married, 26. D-1419.

B.S. in E.E., 1932, Mich. Col. of Min. and Tech., married, 23, desires position in any engg. field. Good scholastic record. Tau Beta Pi. Salary and location, immaterial. Available at once. D-1418.

E.E. GRAD., 1932, single, B.S. VPI, prepared to learn and specialize in any line of E.E. work. Excellent character. Little experience in conduit work. Virginia present address. D-1420.

B.E.E., 1932, U. of Minn., 21, single. Two summers constr., Northwestern Bell Tel. Co. Major in communications. Special investigation of microphones. Desires any position. Not afraid of hard work and satisfied with decent living wage. Location, immaterial. Good scholastic record and character references. Good physical condition. Available immediately. D-1425.

1930 GRAD. in E.E., B.S. from North Car. State College, 25, single. $2^1/_2$ yr. experience in installation of motors and bldg. wiring, 2 yr. with constr. co. in inspecting and testing pwr. transformers and other equip. for substations. Location, East. Available at once. D-1431.

E.E. GRAD., B.S. in E.E., U. of Ill., 1932, 23, single. Ten months long distance telephone test A. T. & T.; 2 months Ill. Bell Tel. Co. Some knowledge of motion picture sound equip. Familiar with vacuum tubes and their applications. Available at once. Location, immaterial. D-1108.

E. E. GRAD., U. of Ill., 1932, single. Fifteen months Westinghouse test. One yr. teaching pub. sch. Desires permanent connection. Available at once. Starting salary and location, immaterial. D-1446.

E.E. GRAD., M.S. in E.E., Iowa St. Col., 1932, 22, single. Best of character and willing to start at the bottom and work up. Short experience in tech. writing. Desires any position that will pay a living wage. Available immediately. D-1276.

E.E. GRAD., B.S. in E.E., Drexel Inst., 1932, cooperative course, 23, single. Nine months in plant dept. of N. J. Bell Tel. Co.; 6 months pwr. plant testing. Desires engg. or teaching position. Location in East preferred. References upon request. Available immediately. D-1466.

E.E. GRAD., U. of Minn., 1930, 25, single. Two yr. experience with Northern States Pwr. Co., including 1 yr. training course and 1 yr. distribution engg. Available immediately. Location, immaterial. D-1477.

E.E. GRAD., 24, single. Broad education and experience, good record; 4 yr. Bell system, 1 yr. elec. mfg. and development. Interested appraisal, aeronautics, air conditioning, refrigerating, utility, mech. engg., or other work. Also experienced secretarial, traffic and chem. mfg. lines. Excellent references. Location and salary, immaterial. D-1475.

JR. ENGR., S.B., 1926 M. I. T., single, 28; 5 yr. experience with large company on design, engg., and constr. on pwr. plants, substation and indoor plants. Desires connection with constr., util., or holding co. Available immediately. D-1487.

B.S. in E.E. CCNY, Tech. high school, 2 yr. radio experience, 21. Desires position as asst., sound, radio work, etc. Moderate salary, references. D-1488.

B.E.E. Northeastern Univ., 1931. Cooperative course, single, 24. Desires position with utility or engg. firm. About $1^1/_2$ yr. on substation and switching yard work, also some maintenance work. Available at once. B-41.

TECH. WRITER, Cornell A.B. and E.E., 23, single. Special training in writing clear concise English fits him to prepare reports, specifications, instruction sheets, publicity, etc. Experienced in pwr., radio, and communications fields. Salary secondary to opportunity in this particular work. Location, immaterial. Available at once. D-1221.

E.E. GRAD., 1931, cooperative course, 23, single. Broad general experience. One yr. with radio concern, 8 months on registers. Literary ability. Salary immaterial. Location, East preferred. Available immediately. D-1414.

YOUNG ENGR., I.E.E. grad. 1930, desires position in jr. engg. work. Has had 4 yr. varied elec. experience including lt., heat and pwr. wiring and automatic relay (telephone type) equip. maintenance. Aggressive, capable and not afraid of hard work. Salary and location, secondary. D-1465.

RENSSELAER P. I. GRAD., elec. engr., 23, single. Wishes position in any elec. field. Has worked 1 summer with Pub. Serv. of N. J. and 1 summer with G. E. Co. in N. Y. City shop. Available at once. D-1158.

E.E., 21, B.S. in E.E.; 1 yr. experience in elec. motor repair and constr. Interested in elec. pwr. engg. Location, immaterial. Available immediately. D-1485.

E.E. GRAD., Northeastern Univ. 1932, single, 21; 1 yr. transformer testing. Good references. Prefer position with utility, but will consider anything. Salary and location, secondary. Available immediately. D-1498.

GRAD.; E.E. 1929. G. E. test experience including work in radio and vacuum tube engg. depts. and with all types of elec. mchy. Utility elec. rate analysis experience covering pwr. companies in all states. Received M.S. in June 1932. Desires an engg. opportunity. D-1036.

Maintenance and Operation

CONSTR. AND MAINTENANCE SUPT., 37, married. Grad. E.E.; 13 yr. experience in the utility field, particularly in engg., constr. and maintenance of distribution and transmission substations. Desires position with large utility with responsibility for the constr., operation and maintenance of substations. B-2885.

E.E., grad., 1929, 26, married; 1 yr. Westinghouse grad. student course and $2^1/_2$ yr. of elec. test. Desires position as maintenance, installation or operating engr. Location, immaterial. Available with 2 weeks notice. C-7431.

E.E., 18 yr. experience on design, construction, maintenance, operating methods and problems, desires position with pwr. co. or firm using elec. driven equip. Univ. grad. B-1923.

Research

Ph.D. in E.E. Calif. Inst. Tech. '32. 2 yr. practical experience as electrician; 5 yr. elec. drafting, teaching and research. Research dealt with measurement of ltg. currents and especially with elec. dehydration of petroleum. Desires research position where experience and training will be useful. Single, 28. Location, immaterial. D-1350.

E.E. 1930, with 2 yr. research work, post-grad. study and excellent scholastic record, desires tech. work, preferably mathematical. Location, vicinity of N. Y. City preferred. D-1183.

E.E., Brown, 1921; Columbia Univ.; 32, single; 5 yr. Western Elec. Co., installation, test, design, automatic telephone equip.; 6 yr. Bell Telephone lab., design, development, research, electromagnetic relays, vacuum tube circuits for cable and radio. Interested; consulting, development, research on above and allied fields. Languages, French, German. Prefers New York. C-1047.

RESEARCH ENGR., specialties, photoelectric color-matching equip.; light sources. B-7066.

TESTING AND RESEARCH ENGR., Phys. tests of materials, metallography, X-ray and spectroscopic structure analysis. Well versed in physics. Languages: English, German, French. Location and salary of secondary importance to opportunities. C-6994.

DEVELOPMENT ENGR., 26, single, E.E. and M.S., high scholastic rating; 3 yr. G. E. Co. research, test and field engg., 2 yr. development of pwr. plant equip. for telephone offices. Location, immaterial. Best of references. Available now. D-1219.

ENGR., 15 yr. automatic printing telegraph development, including 7 yr. with mfr., desires situation, preferably East. Salary consistent with responsibilities. Broad experience with fine high-speed mchy.; sound knowledge of circuits and circuit theory; can handle men; languages, French, Spanish. Available now. D-1459.

B.S. in E.E., Harvard 1924, G. E. test and 5 yr. in research lab. in Schenectady. Research work involving elec. arcs or switching phenomena preferred, but open for other engg. work. Available immediately. D-1486.

E.E. GRAD., 23, Sc.M. M. I. T., Harvard '28; Sc.D. M. I. T. June '32; single, 38; 9 yr. practical experience pwr., business and communication engg.; 2 yr. testing course. Valuable contribution to net-work synthesis. Speaks Swedish, English, German; reading knowledge French. Desires position, well known organization. Available. Location, immaterial. D-747.

Sales

SALES ENGR. OR MFG. AGT., grad. E.E., 32. Over 5 yr. with utility in constr. maintenance and design; over 3 yr. as sales engr. for elec. mfr. including about 3 yr. as jr. exec. Location immaterial for salary position. Pittsburgh headquarters as mfg. agent. D-745.

B.S., E.E., U. of Ill., 1930, single; 2 summers A. T. & T. Co. Student engr. 6 months, Elec. Mach. Mfg. Co. Employed since Jan. 1931, special committee, stresses in R.R. tracks, asst. test engr., U. of Ill. Interested, pwr., a-c. mchy. Experience, sales work. Available month's notice. Salary, promotion primary. Location, secondary. D-1439.

DISTRICT SALES MGR. OR MFRS. AGT.: experienced engg. representative, desires connection with high grade co. that has line of industrial or utility equip. Eastern location preferred. B-4067.

B.S. in E.E., PROF. ENGR., N. J., 34, married. Steel corp. sales engr. 3 yr. contacting archts., engrs., N. Y., N. J.; heat and sound insulation sales engr., 4 yr. contacting architects, engrs., heating trade, plus job supervision; storage battery automotive elec. sales and service 5 yr.; inventive ability and experience. C-75.

Membership

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Oct. 31, 1932.

Baldwin, J. G., Montreal Lt., Heat & Pwr. Consolidated, Montreal, Quebec, Can.
Basinger, C. B., Wind Turbine Co., West Chester, Pa.
Fetterman, R. E., 340 Wilson Ave., Port Clinton, Ohio.
Fracker, H. E., Bell Tel. Lab., N. Y. City.
Greene, A. B. (Member), Florida R. R. Commission, Tallahassee.
Harris, R. S., c/o Lowell Observatory Flagstaff, Ariz.
Hedrick, W. A. (Member), 422 College Ave., N. E., Grand Rapids, Mich.
Hess, W. F., 25 Hawthorne Ave., Troy, N. Y.
Litchfield, N. (Member), c/o Gibbs & Hill, N. Y. City.
Niedurny, W. J., c/o L. E. Myers Co., N. Y. City.
Pitman, J. B., 3110 Lincoln Ave., Alameda, Calif.
Sine, E. R., Box 226, Nassau, N. Y.
Whalley, R., Pacific Elec. Mfg. Corp., San Francisco, Calif.
13 Domestic

Foreign

Alizo, C., Antonio Cia. Annma., Planta Elec. de Valera, Est. Trujillo, Venezuela, S. A.
Banton, F. B. (Member), Cia Colombiana de Electricidad, Barranquilla, Colombia, S. A.
Foulsum, W. C., 16 Bondoran Parade, Mont Albert, Melbourne, Australia.
Gibbes, G. B., Govt. Elec. Dept., St. George's, Grenada, B. W. I.
Kesavan, V. K., Pwr. Station Kottayam Travancore, So. India.
Lautier, V., 37, Sda. San Paolo, Cospicua, Malta.
Rozario, J. F. T., Pub. Wks. Dept., Madras Govt., Madras, India.
Sarda, P. M., Ratan Pole, Nagori Pole, Ahmedabad, India.
Singh, H., Simla Municipal Committee, Idgah, Simla.
Swami, T. V., Elec. Dept., Cocanada, India.
10 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Adams, Albert J., 950—18th Ave., Honolulu, T. H.
Angel, G. H., Gen. Del., City Hall P. O., N. Y. City.
Bohner, C. W., 620—22nd Terrace, Miami, Fla.
Campbell, Charles R., Jr., 270 Seaman Ave., N. Y. City.
Cooper, Lamar S., 1936 Dallas St., Phila., Pa.
Dalas, F. L. Boulder City, Nev.
Deney, Roger W., 685 Sumner-Atlantic Ave., Forest Hills Boro, Pittsburgh, Pa.
Gooding, Chas. C., 1414 K St., Sacramento, Calif.
Keiser, Morris, 1025 King St., Alexandria, Va.
Morita, Kadzuo, c/o Chosen Hydro-Elec. Co., Kankyo-Nando, Korea, Japan.
Neander, M., 182 Pravy Bereg Nevy Kv. 51, Leningrad, U.S.S.R.
Olsson, Oscar G., 361 Mulberry St., Williamsport, Pa.
Schroeder, G., Krivokolenni Pereulok No. 11–16, Moscow, U.S.S.R.
Uline, Wm. A., Northern Elec. Co., Guy & Notre Dame Sts., Montreal, Que., Can.

Engineering Literature

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

Die ABHÄNGIGKEIT der WERKSTOFFDÄMPFUNG von der GRÖSSE und GESCHWINDIGKEIT der FORMÄNDERUNG. (Mitteilungen des Wöhler-Instituts, Heft 11.) By Bankwitz. Berlin, NEM-Verlag, 1932. 53 p., illus., 8x6 in., paper, 3.60 rm.—On the behavior of metals under repeated stress. Vibration diagrams of steel, copper, brass, and aluminum, based upon careful tests, are given and the influence of speed of deformation upon the magnitude of damping and of alternating stresses upon the elastic properties of these materials are discussed.

ANNUAIRE des INGÉNIEURS de FRANCE, 1931. Paris, Loubat, Éditeur. 1070 p, 9x5 in., paper, no price given.—A directory including names of engineer graduates of the 12 principal engineering colleges of France, and members of the French Society of Electricians and of the Society of Civil Engineers of France; about 35,000 names and addresses.

ARCHITECTURAL ACOUSTICS. By V. O. Knudsen. New York, John Wiley & Sons, 1932. … p., illus., 9x6 in., cloth, $6.50. A reference for architects, builders, and others interested in design and construction of buildings, with theory and practical application of architectural acoustics clearly set forth. Essentially practical in character; it gives information upon the absorption of sound, sound insulation, properties of insulating materials and the acoustics of auditoriums and music rooms. The application of acoustics to schools, churches, theatres, and other buildings is discussed at length and liberally illustrated. A book to enable the architect and builder to meet the problems intelligently.

AVIATION and the AERODROME. By H. A. Lewis-Dale. Philadelphia, J. B. Lippincott Co., 1932. 168 p, illus., 9x6 in., cloth, $6.00.—Dealing with the question of sites and the broad aspects of the engg. problems of a more or less specialized character involved in the construction and ground equipment of aerodromes. The treatment is concise and definite, with numerous examples of plans and buildings. The author, since 1914, has been engaged in the construction of aerodromes for the British Admiralty and Air Ministry.

CARL von LINDE zum 90. GEBURTSTAG. Deutsches Museum Abhandlungen und Berichte, Jahrgang 4, Heft 3, 1932.) Berlin, VDI-Verlag, 1932. P. 55–84, 8x6 in., paper, 1 rm.—A brief memorial celebrating the 90th birthday of the famous engineer, with an extract from his autobiography, a bibliography of his published writings, an address upon the fixation of gases of the atmosphere and a short historical account of the evolution of refrigeration.

DANA'S TEXTBOOK of MINERALOGY with an extended treatise on crystallography and physical mineralogy. By E. S. Dana. 4th ed. by W. E. Ford. New York, John Wiley & Sons, 1932. 851 p., illus., 9x6 in., cloth, $5.50.—The new edition of this well-known textbook has been brought thoroughly up to date. Essential changes include new sections upon crystal structure and investigation of it by means of X-rays; also upon the origin, mode of occurrence, and association of minerals. The section upon descriptive mineralogy fully revised and description of about 220 new species added. The last section now includes brief descriptions of all known minerals.

ELEKTROLYTE. By H. Falkenhagen. Leipzig, S. Hirzel. 1932, 346 p., illus., 10x7 in., paper, 23 rm.; bound, 24.80 rm.—An able review of the work of Faraday, Arrhenius, Lewis, van Laar, Milner, Debye, and many others who have studied the theory of electrolytes. The evolution of current theories is traced carefully and comprehensively.

Die FERROMAGNETISCHEN LEGIERUNGEN. By W. S. Messkin and A. Kussmann. Berlin, J. Springer, 1932. 418 p., illus., 10x6 in., cloth, 44.50 rm.—This book is a systematic survey of ferromagnetic metals and alloys presenting in a practical way not only the properties from a magnetic point of view, but also the influence of metallurgical treatment upon these properties. Designed to serve the metallurgist, the physicist, or chemist engaged in research work, and the electrical engineer, it opens with the theory of magnetism; then the author discusses magnetic measurements, the influence of chemical composition and physical state upon magnetic properties, magnetic analysis of metals, physical properties, permanent magnet steels, alloys for dynamos and transformers, alloys for special purposes, and the production of magnetic alloys. It is an endeavor to consider all the alloys now used industrially as well as those for prospective use.

HIGHWAY MATERIALS. By E. E. Bauer. 2 ed. New York & London, McGraw-Hill, 1932. 374 p., illus., 9x6 in., cloth, $3.50. Intended primarily as college text, to give the student a general working knowledge of the qualities of materials for various types of pavements. Besides the methods of sampling and testing, qualities and specifications of road materials and the interpretation of the results of tests are discussed. Specifications and tests of the Am. Soc. for Test. Mats. are used, this edition revised to include its latest practise.

NEGRO HOUSING. Edited by J. M. Gries and J. Ford. Washington, D. C., President's Conference on Home Building and Home Ownership, 1932. 282 p., illus., 9x6 in., cloth, $1.00.—A comprehensive, valuable report, based upon a nationwide survey of conditions. The social, economic, and financial phases of the problem are presented. The committee finds a remedy for the negro citizens inability to obtain sanitary dwellings and privacy, by providing housing acceptable to persons of low incomes through better plans of production for all housing.

SCHWINGUNGEN an FREILEITUNGSSEILEN und ihre DÄMPFUNG durch RESONANZSCHWINGUNGSDÄMPFER. (Mitteilungen des Wöhler-Instituts, Heft 12.) By F. Puritz. Berlin, NEM-Verlag, 1932. 67 p., illus., 8x6 in., paper, 3.60 rm.—A report giving results of experiments upon methods of reducing vibrations in electric lines and masts. Rubber dampers adjusted to the rate of vibration of the mast-wire system were found helpful.

SCIENTIFIC PRINCIPLES of PETROLEUM TECHNOLOGY. By L. Gurwitsch and H. Moore. 2 ed. New York, D. Van Nostrand Co., 1932. 572 p., illus., 9x6 in., cloth, $8.00.—In 1926 Mr. Moore published a translation of Prof. Gurwitsch's well-known book, with additions. This translation he now has revised and expanded to include especially the results of recent American research work. The book discusses the chemistry and physics of petroleum and principal products and methods of distilling and refining them from the scientific point of view without attempt to treat practical questions of technology. As a review of petroleum chemistry, this work should be a welcome addition to literature.

SMOKE: A Study of Aerial Disperse Systems. By R. Whytlaw-Gray and H. S. Patterson. London, Edward Arnold & Co., 1932. 192 p., illus., 9x6 in., cloth, 14s.—Few attempts have been made to explain the behavior of smoke in terms of general principles, or even to correlate its properties with the number, size, and nature of its constituent particles. This volume delineates the scientific study of smoke, based largely upon the last few years of investigations at Leeds. It provides a general survey of the subject, and describes methods of investigation and results obtained, pointing out further lines of research.

STRESSES in SIMPLE STRUCTURES. By L. C. Urquhart and C. E. O'Rourke. 2 ed. New York and London, McGraw-Hill, 1932. 339 p., 9x6 in., cloth, $3.50.—A textbook to set forth clearly the fundamentals of stress calculation in simple structures, without consideration of economics of design. Both analytical and graphical methods are used. A new edition, entirely rewritten, and with new chapters upon the 3-hinged arch and deflection.

TECHNISCHES WÖRTERBUCH VII (Sammlung Göschen 1050). Die wichtigsten Ausdrücke der Elektro- und Radiotechnik. Pt. 3. Deutsch-Französisch. 2 ed. By E. Krebs. Berlin and Leipzig, 1932. 187 p., 6x4 in., cloth, 2 rm.—A concise German-French dictionary of terms used in radio and telephone engineering, similar to the earlier German-English dictionary by the same author. The volume is of convenient pocket size with words well chosen for ordinary needs.

ZAHNRÄDER, Pt. 1. (Werkstattbücher, Heft 47.) By G. Karrass. Berlin, J. Springer, 1932. 60 p., illus., 9x6 in., paper, 2 rm.—A concise work on the design of gears. One of a series upon shop practise. The aim is to present the subject both scientifically and practically upon the basis of current practise and without complicated mathematics.

HOUSE DESIGN, CONSTRUCTION, AND EQUIPMENT. Edit. by J. M. Gries and J. Ford. Washington, President's Conference on Home Building and Home Ownership, 1932. 325 p., illus., 9x6 in., cloth, $1.00.—The program for raising the standard of American housing adopted December 1931 by the President's Conference on Home Building and Home Ownership has resulted in reports by experts. This one is the work of committees composed of well-known architects, engineers, and home economists from all parts of the country. Recommendations are based upon practical experience and essentials of good practise; also better coordination of effort in the building trade is discussed indicating how building costs may be lowered for the wage-earner. Much useful information for architects, builders, and prospective owners is given.

HYDROGEN IONS. By H. T. S. Britton. 2 ed. N. Y., D. Van Nostrand Co., 1932. 589 p. illus., 9x6 in., cloth, 25s.—An exhaustive, critical summary of present literature upon methods of determining the concentration of hydrogen ions, the importance of these ions in general chemistry, their rôles in industrial processes, and the value of hydrogen-ion concentration measurements for purposes of control. The discussions of the importance of hydrogen-ion concentrations in the electrodeposition of metals, in tanning, sugar manufacture, pulp and paper-making, water purification, corrosion, sewage disposal, ceramics, and flotation will be useful to engineers wishing a concise introduction to modern progress. Thoroughly revised.

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Industrial Notes

Lincoln Appoints G. E. Tenney.—Announcement has been made by the Lincoln Electric Company, Cleveland, of the appointment of G. E. Tenney as sales manager of its Chicago district. The Chicago offices are located at 1455 West 37th Street, where a sales and service organization is maintained for all Lincoln products, including "Shield-Arc" welders, welding supplies, and "Linc-Weld" motors.

Rapid Reversing Motors.—The Louis Allis Company, Milwaukee, announces a new line of rapid reversing squirrel cage motors, capable of as many as sixty reversals per minute continuously without overheating. Such high rates of reversals have been made practical through light-weight rotor construction, efficient ventilation, high torque characteristics, and shock resisting cast iron frames.

New Disc Switch.—The Square D Company, Detroit, has recently developed a new type of disc switch. The new switch has several advantages over standard designs, including front operation, and requires little mounting space. It has a quick make and break action and may be obtained either fused or unfused. Copper switch contacts reinforced by rustless steel springs, insure constant pressure and reduced heating. The switch is rated for either 30 or 60 ampere, single pole, two pole, two wire solid neutral or three wire solid neutral.

A New Liquid Insulator.—A new synthetic liquid insulator which has been announced by the General Electric Company not only has the advantages of mineral oil as an insulating and cooling medium for electric equipment but in addition is non-inflammable and non-explosive. Designated by the trade name Pyranol, the material is produced in different forms for different purposes. For economic reasons, mineral oil will probably remain in general use for years, according to General Electric engineers at Pittsfield, Mass., but commercial installations of Pyranol indicate numerous applications where the new material is especially valuable. Capacitors can be made physically smaller per microfarad, with increased reliability; and the higher cost of transformers with Pyranol is justified when the equipment must be completely proof against fire and explosion hazards. Since the liquid is a solvent for some materials ordinarily used in electric equipment, particularly transformers, the apparatus must be designed specially for its use. Its dielectric constant (specific inductive capacity) is practically that of solid insulations, and its dielectric strength is of the same high order as that of mineral oil.

The liquid is chemically stable and it resists oxidation, so that there is no sludging after continued exposure to heat or air. It demulsifies, or separates from water, more than twice as rapidly as does mineral oil, and the moisture rises to the surface from which it may be evaporated. Viscosity and freezing point can be varied to suit conditions without affecting other qualities of the liquid. When Pyranol is subjected to an electric arc, the principal product is hydrogen chloride, an irritating but not actively poisonous gas which can be removed by an absorption device or piped to the open air for dissipation.

Trade Literature

Lightning Arresters.—Bulletin 14325, 8 pp. Describes valve type lightning arresters. Line Material Co., So. Milwaukee, Wis.

Arc Welder.—Bulletin, 8 pp. Describes the new Lincoln "Shield-Arc" welder. The Lincoln Electric Co., Coit Rd. and Kirby Ave., Cleveland, O.

Resistance Standards.—Bulletin 100, 6 pp. Describes resistance standards and resistance measuring devices. Rubicon Co., 29 North 6th St., Philadelphia, Pa.

Carbon Brushes.—Catalog 13, 24 pp. Describes carbon brushes for single phase and other fractional horsepower motors. Boxill-Bruel Carbon Co., Columbia Park, O.

Air-Break Switches.—Bulletin 9324, 4 pp. Describes gang operated air-break switches for low cost construction. Line Material Co., Milwaukee, Wis.

Electric Equipment for Mine Hoists.—Bulletin GEA 1593, 24 pp. This bulletin is descriptive of General Electric practise and accomplishments in mine-hoist service in both coal and metal mining. General Electric Co., Schenectady, N. Y.

Stainless Steel Tubing.—Bulletin. Describes Carpenter stainless welded tube made from cold rolled stainless strip steel. Both the inside and outside surfaces of the tube represent surface metal from the original ingot. The Carpenter Steel Co., Welded Alloy Tube Div., 100 Broadway, New York.

Smoke Density Meter.—Bulletin. Describes the Brown smoke density meter which has been under development for a number of years, for recording and measuring the quantity or the color of smoke emission. The Brown Instrument Co., Wayne & Windrim Sts., Philadelphia, Pa.

Water Softeners.—Bulletin, 36 pp. The application of Zeolite water softeners to the treatment of boiler feed water is outlined; profusely illustrated with photographs and diagrams, and contains tabulated data, conversion tables, factors, reactions, etc. The Permutit Co., 440 Fourth Ave., New York.

Rubber Paints.—Bulletin, "Acidseal Paints." Describes a recently developed line of rubber paints. These paints have as a base a commercial form of rubber isomer, and retain the elastic properties of rubber, conforming to the expansion and contraction of the surface covered, and minimize the corrosive action of acids, alkalies, and chemical fumes. The B. F. Goodrich Co., Akron, O.

Industrial Lighting Equipment.—Catalog 219-A, 64 pp. This new catalog describes each unit plainly and lists them in a manner easy to find. A complete line of equipment is covered including new units, low priced industrial floodlights and quick change Wemco reflectors and sockets. Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Industrial Scales.—Bulletin, 8 pp. Describes the improved line of Kron automatic industrial scales. Included are dial track scales, portable pan, portable platform, dormant platform, bench, hopper, crane, and pitless suspension types. All have been completely redesigned and the dial and lever mechanism considerably simplified. The Kron Co., Bridgeport, Conn.

Circuit Breakers.—Bulletin 1771-B, 8 pp. Describes manually and electrically operated oil circuit breakers, 7,500 and 15,000 volts, especially suitable for indoor power house use where space is restricted. De-ion grids have been used in some of the units. Bulletin 1958, 12 pp., describes another range of De-ion grid oil circuit breakers for indoor service in voltages from 15,000 to 34,500 and interrupting capacities from 500,000 to 2,500,000 kva. Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Propeller Turbines.—Bulletin 38, 8 pp. Describes I. P. Morris propeller turbines having adjustable blades and fixed gates. These turbines are intended primarily for low heads and are designed to supply an efficient unit at a price lower than the price of the adjustable gate-adjustable blade propeller turbines with their two complete sets of control equipment. They are particularly indicated where the revamping of existing and less efficient plants is in contemplation. The bulletin includes power-efficiency curves, line drawings of the turbines and a "Chart of Characteristics for Standard Turbines" in two colors. Baldwin-Southwark Corp., I. P. Morris Div., Philadelphia, Pa.

Meter Test Block.—Bulletin CA 25, 8 pp. Describes a new type of plug-in meter test block, which permits easy connection and removal of the meter. The new block does away with meter loops and cross-overs in the meter connections. All cross-overs are provided in the base of the new block and the meter terminal connections slide down over semi-rigid connectors. Furthermore, unsightly wiring is eliminated, time is saved in installing or removing meters, and the meter links can be separately inserted or removed without disturbing the meter or base. The wiring order is the same as employed in ordinary test blocks and testing is accomplished with standard links, which are supplied. The block is built in indoor and outdoor meter cabinets. Switch and Panel Division, Square D Co., Detroit, Mich.